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SHIPBUILDING SUPPLY CHAIN INTEGRATION PROJECT

Interim Report

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TABLE OF CONTENTS

Executive Summary

US shipbuilders now hold less than 1% of the world market for commercial ships. In the 1970s US shipbuilders built an average of 20 seagoing commercial ships per year, now that number is less than two per year. It seems clear that the US shipbuilding industry cannot currently compete in the world market for seagoing commercial ships. The two primary sources of this problem are low productivity, in some cases lower by a factor of 2 or 3 than the best in the world, and high material costs. High material costs are especially a problem since material and equipment represent more than 50% of the cost of a delivered ship. This report will focus on the problems of material costs, in particular as they are affected by relations with suppliers.

The Shipbuilding Supply Chain Integration Project was designed to improve understanding of best practices in supply chain management in the marine industry. The project focused on US shipyards and suppliers, foreign shipyards and suppliers, and a US construction firm. The intent was to obtain a baseline to show how the US marine industry acts as compared to the foreign marine industry and a somewhat comparable non-marine industry in the US.

This report documents *interim results* at the half-way point from the Shipbuilding Supply Chains study. Results are presented in two ways. First, we describe specific findings from the firms we visited. This is done by characterizing best practices at specific companies and by making comparisons between different types of companies. Second, we present a case study for each firm we visited in the project. The report ends with conclusions and recommendations to the shipbuilding industry for how they can improve supply chain management. Note that additional visits to shipbuilders and suppliers will be made after this interim report is issued. After those visits are made this report will be revised and issued as a final report.

As part of the project so far we have visited six shipyards: Alabama Shipbuilding, Avondale Shipbuilding, Newport News Shipbuilding, and National Steel and Shipbuilding Company (NASSCO) in the US, and Fincantieri and Odense Steel Shipyard in Europe. We visited five suppliers: Hopeman Brothers Marine Interiors, Jamestown Metal Manufacturing, MAN B&W in Copenhagen, MAN B&W in Augsburg, and Cegelec. In addition, we visited one non-marine firm, Black and Veatch, one of the largest construction firms in the world.

Results

Based on the visits we made in the marine industry as well as the other experiences available to the study team, we identified *Best Practices* in five areas: Supply Chain Management (SCM) Strategy, SCM Planning, Mechanisms, Systems, and Activities (Figure S-1).

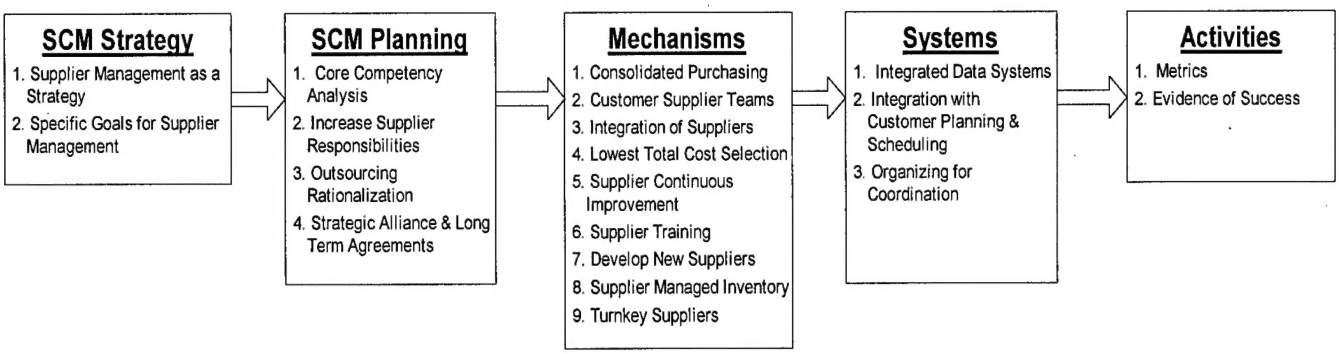

Figure S-1. Best Practices in Supply Chain Management

For the most part we have seen evidence of these Best Practices in shipbuilding. In the case of two best practices we know of no shipbuilding examples so far. However, we are convinced the practices can and should be applied to shipbuilding. We have tried to make the case for this in the report.

Conclusions

These conclusions should be considered tentative since this is an interim report. Additional site visits will be made and more information will be collected, perhaps leading to different or additional conclusions.

1. **SCM in shipbuilding lags other industries**. The two shipbuilding firms exhibiting the most Best Practices have substantially more progress to make before they will match the leaders in the automotive or aerospace industry sectors. The use of these practices is relatively new in both companies, and evidence from other firms suggests that as long as half a decade or more is needed before the Best Practices really take hold. Top management needs to place, or maintain, a priority on supply chain management, and have the vision and stamina to stay the course.

2. **Most SCM approaches can work in shipbuilding**. Wide variations in supply chain management philosophies and practices exist in both the European and domestic marine industries, as is true of any industry sector. Some companies on both continents have instituted, or are instituting, many of the Best Practices, while others appear to have instituted almost none.

3. **SCM in shipbuilding is hampered by a lack of consensus on the structure, function and dynamics of the integration of ship production and SCM**. Real progress toward reducing material costs and improving delivery time depends on a deeper understanding of the integration of internal processes and those of suppliers into a "shipbuilding production system," analogous to the Toyota Production System. Successful manufacturing firms have learned to design supplier networks that minimize waste and maximize the benefits of supplier knowledge as well as process and material management capabilities. This is only in its infancy in shipbuilding.

4. **Good practice in SCM leads to business success**. Companies in the automotive, aerospace, construction and other industry sectors regarded as leaders in supply chain management are also leaders in important business metrics such as profitability, market share growth, product development time, and production cycle time. These companies attribute a significant part of

their business success to their supply chain management philosophies and practices. Most of the Best Practices employed by these firms can be adopted or adapted by the domestic marine industry, and similar benefits can be expected. Almost all of the Best Practices we identified were in use in at least one marine industry firm.

5. **Shipbuilding lags in the use of electronic commerce technologies**. In general, this industry appears to lag both the automotive and aerospace industries in the use of electronic commerce (such as EDI and product data exchange) with suppliers. This was true for both the domestic and foreign companies we saw. In some of the companies we visited, communication is only by telephone and fax, and few companies exchange technical data with suppliers electronically.
6. **Supplier relations are more adversarial in the US**. Relationships between domestic shipyards and most of their suppliers tend to be significantly more arms length and adversarial than is the case in Europe. Experience from other sectors, particularly automotive and aerospace, shows that suppliers are much more responsive to the needs of their customers when close relationships exist and communication is frequent and open. The sourcing practices of some of the domestic shipyards have the effect of making relations with many suppliers far more adversarial than necessary.
7. **US shipyards lag in scheduling practices**. Domestic shipyards have much more difficulty in creating and maintaining accurate schedules for both engineering and construction than do the European yards we visited. Inaccurate schedules affect many aspects of supply chain management, including increased supplier costs, problems with timeliness and completeness of vendor-furnished information, and diminished trust between the yard and its suppliers. The root causes of poor schedules were not clear, and merit further study.
8. **DoD requirements do not prohibit good SCM**. DoD and statutory requirements do not prohibit the use of best practices, but they are often a constraint and at times prevent accessing commercial companies. CICA (Competition In Contracting Act), and variations in its interpretation, makes it more difficult to effect long term relationships with suppliers and to select suppliers on the basis of lowest total cost. The FASA (Federal Acquisition Streamlining Act) should remove remaining barriers to sourcing from commercial firms.

Recommendations

This report makes the following recommendations:

- Recognize the importance of SCM as a key cost and schedule driver.
- Use the results of this and other studies to better understand the key process linkages and underlying dynamics of ship production and its impact on suppliers. Use that knowledge to build a shipbuilding "production system" to provide a better context into which Supply Chain Management Best Practices can be inserted.
- These SCM Best Practices should be demonstrated on a *pilot* basis before attempting widespread deployment. A pilot can be used to demonstrate the business case for the technology or business practice involved. It also insures that the technology or practice is modified to suit the specific situation for which it is being inserted.

- The Best Practices should not be adopted on an ad hoc basis, but rather in an orderly, planned manner. Figure S-1 represents the approximate order in which this should be done. All shipyards that we visited are already doing some of what we recommend as Best Practices, however they still have a long way to go.
- In areas other than SCM, the industry should focus on improving scheduling practices, because problems with this are the source of several SCM problems, including Vendor Furnished Information.
- The industry should seek to take advantage of changes in Federal procurement policies and switch to commercial contracting approaches if they aren't in use already.

The US shipbuilding industry did not get in its current position by accident. The combination of dependence on a single government customer and protectionist legislation has resulted in a relatively uncompetitive industry. The solution to this lies in a concerted effort by one or more companies in the industry to return to commercial competitiveness by *focusing on competitive processes*. An ideal approach would be to develop a process-oriented best practice "production system" for the shipbuilding industry. Indeed, the Maritime Agility Group (1996) has taken a first step toward an outline of such a system. What remains is to assemble the details and learn how to make it work. In this study we have taken a small first step toward that end. Shipyard-supplier relations were a key element of the Maritime Agility Group's strategy. Adoption of the Best Practices in this report would result in a substantial improvement of shipyard-supplier relations.

While all of the Best Practices are "good" things to do, which will have the most impact? We have little hard data about the impact of these Best Practices as applied to US shipbuilding. What we have been able to do is to establish that many of the Best Practices are dependent on other Best Practices being in place. For example, you may not be able to do Supplier Training effectively unless you already have a strategic alliance with a supplier. The only way to find out which Best Practices have the most impact is to try them. Such trials cannot be done on an industry-wide or even company-wide basis. Instead they should be done on a *pilot* basis.

In the shipbuilding industry, a pilot of several Best Practices could be conducted on a limited scale, with one or two shipyards and a handful of suppliers. This approach to demonstrating the benefits of Best Practices has been very successful in the automotive industry, which historically has been very conservative and resistant to change. We believe the shipbuilding industry is no more resistant to change today than automotive was a decade ago. Therefore, we have every reason to believe that a process like this could work in shipbuilding.

Introduction

The US shipbuilding industry finds itself pressed on many sides. The two most obvious sources of pressure are dwindling government orders and the industry's inability to capture international commercial ship orders due to the significant price differential with foreign shipbuilders. US shipbuilders now hold less than 1% of the world market for commercial ships. In the 1970s US shipbuilders built an average of 20 seagoing commercial ships per year, now that number is less than two per year (NSRP, 1998). With recent adverse experiences, it will probably be down to zero for international orders. Some in the industry do not see this as an immediate problem since they believe the need to replace Jones Act ships will satisfy their needs for the next 5-10 years. However, many Jones Act shipowners are balking at ordering at the current high cost of US-built commercial ships.

In the marine industry over 50% of the cost of the delivered product is for material and equipment. For a passenger ship it can be almost 75%, especially if many turnkey subcontractors are involved. Over the past 20 years US shipbuilders have accepted that their productivity was significantly lower than world class shipbuilders, sometimes by a factor of 2 to 3. It is only recently, however, that they have acknowledged a material price differential of up to 33%. Indeed, one recent report suggests it may be as high as 50% (NSRP, 1998). Clearly, material costs are one of the major sources of the lack of international competitiveness of the US marine industry.

The US Navy is similarly challenged by a number of basic problems as they predict their need for future shipbuilding, including:

- keeping U.S. shipyards in business to maintain the industrial base,
- acquiring affordable ships,
- shortening the pre-contract, design, and building cycle times, and
- maintaining ships.

It is clear that without significant improvement in productivity of the US shipbuilding industry it will wither and shrink to the minimum required to sustain naval shipbuilding. Shipbuilding will then become an even more difficult business due to the inherent inability of the military to plan a continuous sustaining level of production, as opposed to periods of high need followed by large periods of low need for shipbuilding capacity.

There has been considerable benchmarking of the US shipbuilding industry with other shipbuilding countries and also with other industries, both US and foreign. In these studies, improved management of supply chains has emerged as a potential way to improve US shipyard performance. In a report by the Maritime Agility Group (1996) entitled *21st Century Agile Shipbuilding Strategies: Infrastructure and Business Process Opportunities*, the industry considered the improvement in the relationship between the shipyard and its suppliers as one of the most important priorities. Specific areas that were considered significant were the information exchange between the shipyard and its suppliers, early involvement of suppliers in the design process, and a focus on the cost of purchased material. The report was the result of an industry-led self-examination identifying the need for work to improve the shipyard supplier chain as a factor in achieving agility and competitiveness.

The performance of both the automotive and aerospace industries has improved significantly through improved management of supply chains. For example, much of the widely admired improvement in Chrysler's performance as the low cost and fastest time to market US automotive producer has been attributed to their excellent relations with their suppliers (Dyer, 1996). In contrast, much of General Motors' difficulties over the past decade has been attributed to their exceedingly poor relations with suppliers. In the aerospace industry (AIAG, 1998a), Boeing has attributed many of its successes over the past few years to its supplier relations – e.g., reducing maintenance time on engines from 15 hours to 3 for the 737 next generation as a result of working closely with GE Aircraft Engine, their engine maker (AIAG, 1998a). Equally, many of Boeing's manufacturing problems over the past 2 years have been widely attributed to the inability of suppliers to keep up with Boeing's schedule. While the automotive and aerospace industries are substantially different from shipbuilding, shipyards can learn important lessons that can be *adapted* to their industry.

The Analysis of Shipbuilding Supply Chains project was initiated in November, 1997 by the Office of Naval Research Manufacturing Technology Program to improve understanding of best practices in supply chain management in the marine industry. The project focused on US shipyards and suppliers, foreign shipyards and suppliers, and a US construction firm. The intent was to obtain a baseline of best practices to show how the US marine industry acts as compared to the non-US marine industry and a somewhat comparable non-marine industry in the US.

This report documents *interim results* at the half-way point from the Shipbuilding Supply Chains study. Results will be presented in two ways. First, we will report results by describing specific findings from the firms we visited. This will be done by describing best practices we observed at specific companies and by making comparisons between different types of companies. This discussion will include background from other industries with which we are familiar. Second, we will present a case study for each firm we visited in the project in an Appendix. The report will finish with a set of conclusions and recommendations to the shipbuilding industry for how they should proceed to improve supply chain management. Note that additional visits to shipbuilders and suppliers will be made after this interim report is issued. After those visits are made, this report will be revised and issued as a final report. This will almost certainly result in additional best practices and may result in changes to the recommendations and conclusions.

Study Methods

The Companies

Shipyards

We visited six shipyards: Alabama, Avondale, Newport News Shipbuilding[1], and NASSCO, in the US, and Fincantieri and Odense in Europe. Avondale, NASSCO[2] and Newport News were selected as being representative of the larger US shipyards, while Alabama was selected to represent a smaller US yard. The European shipyards were selected because of their relative success in their niches – Fincantieri[3] in cruise ships and Odense in container ships. One shipyard and several suppliers we sought to visit refused to participate because they felt their supply chain management practices would not work in the US.

Suppliers

Five suppliers, two in the US, two in Europe, and one with a presence in both the US and Europe were visited. We selected only suppliers that we believed would have a high level of design content that must be customized to the specific ship being built. In such a case, the ship design must also be modified as the equipment is being designed. Hence, a close relationship should be especially important. We selected joiner work subcontractors, engine producers, and controls makers.

Joiner work subcontractors fabricate and install the living quarters, galley and other working spaces on the ship. This must be done in close interaction with the shipyard to insure efficient use of space and that functional requirements are met. We visited Hopeman Brothers Marine Systems in Waynesboro, Virginia, and Jamestown Metal Marine Sales, Inc. in Boca Raton, Florida. Both companies provide turnkey joiner work systems.

We visited two divisions of a diesel engine maker in Europe – MAN B&W Diesel in Copenhagen, Denmark and in Augsburg, Germany. These companies have less interaction during the design process than either the joiner work subcontractors or the controls makers. The Copenhagen division does primarily R&D and design for 2-stroke diesel engines, the production of which is mostly done under license. The Augsburg division does production and sales as well as R&D and design for 4-stroke diesel engines. Augsburg is increasingly involved in selling propulsion systems rather than just engines.

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[1] Newport News Shipbuilding had not approved its case study at the time this Interim Report was issued. We have therefore removed all substantive mention of NNS from this report. Description of NNS practices will be included in the Final Report when it is issued.

[2] The visit to NASSCO and the subsequent case study were completed prior to NASSCO's acquisition by General Dynamics in October, 1998. We have not attempted to take any changes that might occur due this acquisition into account in this report.

[3] Because Fincantieri is owned by the Italian government, some readers have suggested that they may not provide a useful basis for comparison in this study. In response, we urge the reader to consider the case study on the company in the Appendix to this report. In terms of practices and culture, Fincantieri looks remarkably like a very good US manufacturing firm, comparable to some of the better ones we have seen. Fincantieri management claim they have experienced no interference from the Italian government. The extent to which they have been able to reduce staff and outsource suggests this to be true; indeed, it would be remarkable even in many large US firms.

Ship controls makers use standard parts to build control systems for various parts of the ship. The control system is custom designed for the specific ship and is the result of substantial interaction with the shipyard. We visited Cegelec who provides turnkey electrical propulsion and ship power systems that include the electronic controls. Cegelec was visited at its sales office in Pittsburgh. Later in the project we will also conduct a video conference interview with managers from Cegelec's engineering offices in England.

Non-marine Firm

We visited Black and Veatch, a construction company that performs work that has some similarities to shipbuilding. The construction industry is very much dependent on effective management of their supply chain. Black and Veatch is one of the largest construction firms in the US. The division we visited does engineering, procurement and construction for large power plants world-wide. Substantial interaction is required with various subcontractors and partners during the planning and construction of power plant. While not all practices we observed at this firm will be transferable to the marine industry, many are relevant and interesting.

Respondents

The fundamental approach to this study was that we wanted to learn about what shipyards and their suppliers were actually doing, rather than what they would *like* to do. To that end, we planned to visit each company and talk to working level engineers and purchasing and sales staff, as well as managers. The intent was to avoid the typical "industrial tourism" that involves making a tour of company and listening to presentations that have been carefully screened by top management and their public relations staffs. We sought to interview the following types of people in each company we visited: executive, engineering manager, line design engineer, purchasing manager, line purchasing agent, sales manager and salesperson (suppliers only), and production manager.

All interviews were "semi-structured," meaning we had a set of questions (indeed a very long set) for each type of respondent, but we were free to ask additional questions and to follow interesting threads in the conversation. Interviews were conducted by 2-4 individuals, usually with a single person in the lead, with the others asking additional questions as needed and taking notes.

All US companies and one foreign company followed this process to the letter – we conducted our interviews there in textbook fashion. One foreign company modified things a bit – we met with all the right people (and others as well), but they had prepared presentations that answered most (if not all) of our questions (the questions had been sent to them in advance). In this company we had the opportunity to ask additional questions, but these were usually questions that had been provoked by the presentation, rather than those off our question list (which had typically already been answered). Two other foreign companies only allowed us to meet with one or two people who attempted to answer our questions as best they could. We learned quite a bit at both of those sites, but our degree of learning was less than if we had been able to conduct a full set of interviews.

The Interviews

We developed a separate interview protocol for each type of respondent (executive, engineering manager, etc.) at each type of firm (shipyard, supplier, non-marine). The basis for the overall set of protocols was a model of supply chain management that we developed in earlier work. Figure 1 is taken from a study done for US Air Force ManTech (Fleischer, Carson, and White, 1994). It represents a process by which strategy drives planning, which drives a set of mechanisms used for supply chain management. These mechanisms are in turn affected by the organization of the company involved and its suppliers. All of this is affected by the various metrics in use.

While we wanted to cover as many elements in the model as possible, we recognized that it would be necessary to ask different people about different issues. Hence, only the executive was asked about the items above the planning box, and even there we had to limit ourselves to fairly high level questions about strategy. The purchasing interviews focused on rationalization and supplier management mechanisms, while the production, purchasing and engineering interviews focused on roles and responsibilities and activities. In this way we customized each interview protocol to focus on those areas of the model for which the respondent was best suited.

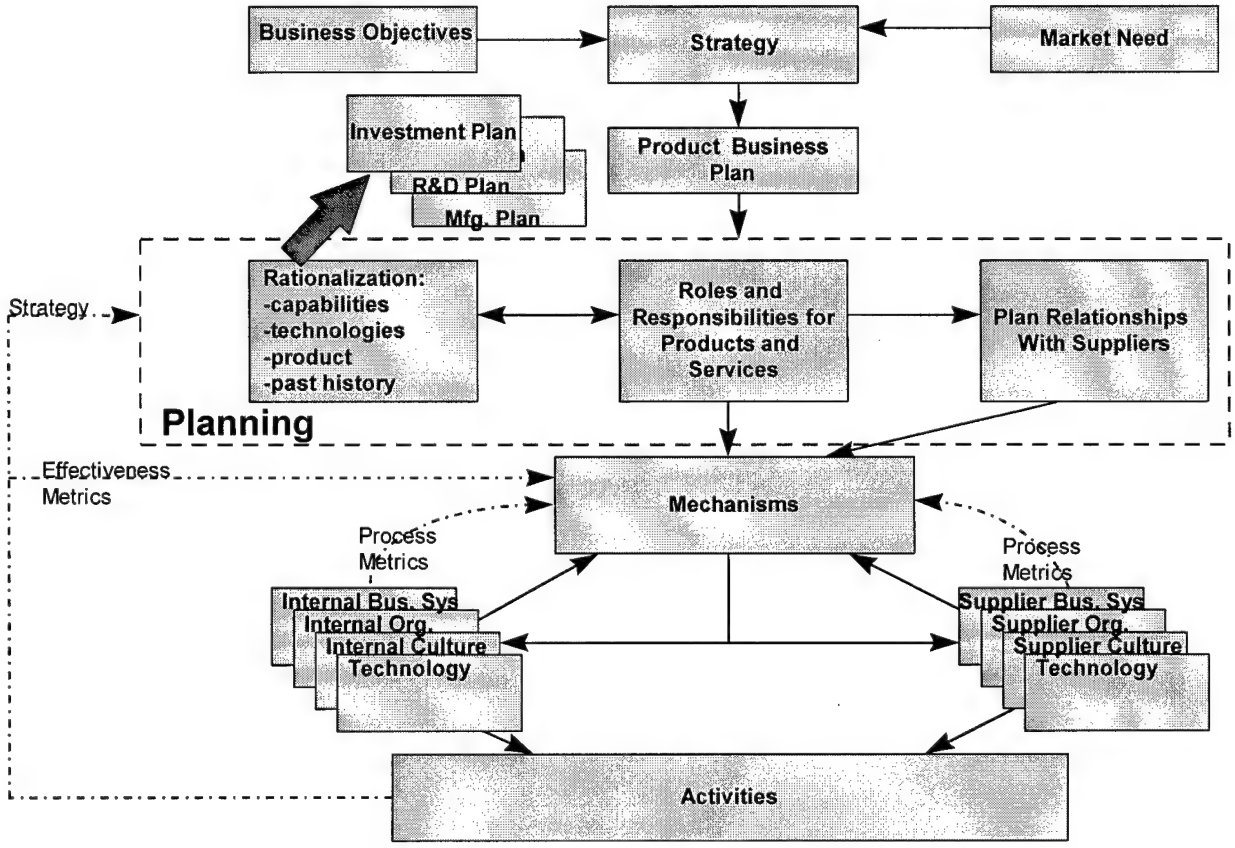

Figure 1. Proposed Supplier Management Process

Analysis and Reporting

After each visit we prepared a detailed case study for that site. The case study report was sent back to our point of contact at the company to check for accuracy and to insure that it did not

include anything that was proprietary. The result of this process can be seen in the Appendix[4]. The cases served as the raw data for our report.

Using a simplified version of the model in Figure 1, we looked for best practices in the cases and report on those below. The team who worked on this project has members with extensive experience in the analysis of supply chain management practices in the automotive and aerospace industries. In their previous work with those industries (Fleischer and Liker, 1997; Fleischer, Carson, and White, 1996) the team members developed lists of best practices in supply chain management for those industries. Combined with other team members who have extensive shipbuilding experience we developed a preliminary set of practices. We were naturally concerned that any best practices we recommend be applicable to shipbuilding. In most cases we have observed evidence of the use of these best practices in shipbuilding to good effect. In the case of two best practices we know of no shipbuilding examples so far. However, we are convinced the practices can and should be applied to shipbuilding. We have tried to make the case for this in the report.

It is important for the reader to recognize that we are not suggesting in this report that shipyards blindly follow the lead of these other industries and simply adopt best practices from them. Instead, shipyards should look at how those Best Practices operate and consider how they can be *adapted* to the US shipbuilding situation.

[4] At the request of the shipyard all specific information about Alabama Drydock, including the case study, was excluded from this report. The Newport New Shipyard Case Study had not yet been approved at the time the this Interim Report was issued and is not included in the Appendix at this time.

Study Results

A detailed discussion of each site can be found in the case study section in the Appendix. Each site we visited did many things well and many not so well. Since our purpose is to identify best practices in supply chain management for the marine industry, we have not attempted to "assess" the current state of the US marine industry in this section. Not only has that been done elsewhere (e.g., NSRP, 1995, 1998; Lamb, et al, 1995), but it would not serve our purpose well since that would place focus on what is being done poorly rather than on how to improve using the identified best practices.

The presentation of results is divided into five primary sections: **Supply Chain Management (SCM) Strategy, SCM Planning, Mechanisms, Systems, and Activities**. This is a simplification of the model in Figure 1. Within each of those sections we start with a brief description of the topic and then provide results in form of specific Best Practices. Each Best Practice discussion is in three parts (when appropriate):

- *Best Practice Description* – this section defines a Best Practice often starting with reference to other industries (typically automotive, aerospace or defense electronics). We then describe how the marine industry appears to be performing on each Best Practice based on our site visits. Marine industry activities in each Best Practice area are found indented and in italics. We have tried to present the marine activities with only minimal detail. The interested reader should go the specific case study in the Appendix for more detailed information on Best Practices in any company included in the study.
- *Comparison of US vs. Foreign Firms* -- when it is possible to generalize, we compare how US firms differ from foreign firms.
- *Comparison of Shipyards vs. Suppliers* – where yards see things differently from their suppliers we describe how they differ.

Figure 2 shows the Best Practices in the five sections.

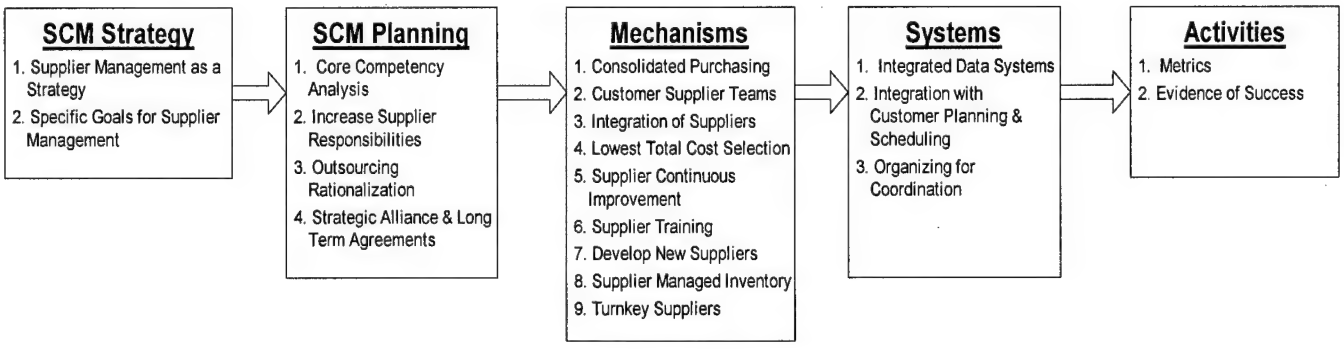

Figure 2. Best Practices

SCM Strategy

SCM Strategy includes all of the high level activities the company does to plan its product and basic approach to business. While there are a wide variety of strategy-related best practices, in this section we will be concerned only with strategies that focus on supply chain management.

We recognize that other, more specific strategic choices have a major effect on supply chain management – e.g., the decision to enter a specific market will affect the nature of the supply chain needed. Nonetheless, those decisions are not focused enough on the supply chain issue to merit our attention here. Also, while strategy covers a certain amount of planning (e.g., strategic planning), the planning section (below) covers only that planning which specifically pertains to supply chain management. Two Best Practices are included in this section:

1. Supplier Management as a Strategy
2. Specific Goals for Supplier Management

Supplier Management as a Strategy

Companies widely regarded for their excellence in supply chain management view the supplier management function as central to their business performance and long term success. Top management in these companies believes the supplier management function to be extremely important and often treat it as a core competency. In many highly-regarded firms there is a clear champion for supplier management excellence at the Vice President level.

Recognition of the importance of supplier management is a critical step toward instituting other Best Practices. Where the function is not viewed as important, relatively few operational Best Practices are in place and the status of the individuals involved is relatively low. Where the function is seen as important, the individuals involved are more strongly supported by training, information systems and other company actions that clearly indicate the high status of the supplier management function. Most of those who have recognized the importance of the function seem to have come to that recognition by observing the success of other firms, but some have come to it out of desperation, notably Toyota, Honda and Chrysler.

In 1989, Chrysler (Dyer, 1996) was in dire straits, having closed three plants in 18 months, with a $4.5B unfunded pension fund, and a record loss of $664M in the fourth quarter of 1989. The President of Chrysler instituted three fundamental changes, one of which, in recognition of their importance, was to implement new methods of working with suppliers, drawing on lessons learned from Honda, AMC and Mitsubishi. By 1996, Chrysler had reduced product development time by 40 percent, increased market share from 12.2 to 14.7 percent, and increased profit per vehicle from $250 to $2,110 (in 1994). Recognizing the importance of suppliers, and then taking action, was key to that business performance.

A number of defense producers have also made this leap. By changing its relationships with suppliers and instituting massive change in its internal supply base management processes, Rockwell Collins (Fleischer, Carson, and White, 1996) has experienced year by year reductions in material cost while steadily increasing its win rate on proposals to around 70 percent. Another producer of aerospace equipment, faced with the big drawdown in defense orders coupled with a similar downturn in its other markets, recognized the importance of its supply base to reducing total costs and increasing its competitiveness for the remaining business. The company dramatically changed its philosophy of supply base management, and totally overhauled its internal practices and structure. The change is too recent for good study, but the company ardently believes it is paying off.

Black and Veatch (B&V), a construction firm that we visited, demonstrates many of the tenets of good supply chain management. Interestingly, they also play the role of supplier on many

projects, and this may have enhanced their ability to see suppliers as integral partners in an extended enterprise. As an example, they have a program called "Partner of Choice." In this program, they work to develop a close relationship with vendors under the assumption that such a relationship will be better for each party. Part of this relationship is a greater level of data sharing than with non-Partners of Choice. As part of the program, they try to do mutual help in terms of streamlining processes, reducing cycle time, and cost savings. In the case of major vendors, B&V assigns a Principal to each who is tasked with making sure that they understand each other's needs. The assignment of a Principal is a clear and tangible sign that they see vendors as important to their corporate goals.

Marine Best Practice[5]

Fincantieri has clearly recognized the importance of its suppliers and has made relations with suppliers one of its five fundamental processes. They are acting on this by instituting far-reaching changes in how they will manage their supply base. They utilize many of the recognized supply chain management approaches, such as partnering, long term agreements, and customer /contractor/supplier integrated teams. It should be realized that for the last year of the ship construction schedule, there are more subcontractor personnel on board a cruise ship that they are building than there are Fincantieri personnel.

In the US, NASSCO appears to be the most strategic in the way they approach suppliers. It is clear that NASSCO's strategy for achieving improved competitiveness depends on stronger links with suppliers. NASSCO is using many of the recognized supply chain management approaches such as strategic alliances, partnering and teaming with suppliers. This effort appears to have strong top management support.

Specific Goals for Supplier Management

Companies demonstrating excellence in supply chain management have specific goals that back up the typical banner statements (e.g., "cheaper, faster, better", "fast to market", "best X builder in the world", etc.) with clear objectives against which quantitative metrics can be applied (e.g., "increase the number of inventory turns by 20% this year", or "reduce average production span by 10% this year, etc.). Better companies will have specific initiatives involving their suppliers that they can relate directly to such quantitative objectives. Excellence is achieved when companies clearly recognize that specific corporate goals for gains in market share, profitability, speed to market, etc. are not achievable without important contributions by suppliers, are able to think through how their suppliers' performance has to change, and can determine what changes are needed in their supplier management practices to foster that performance.

One producer of electronic instruments and controls for industrial and scientific customers set specific goals to increase inventory turns, increase market share and improve profitability over a several year period. Many changes were needed in the company, but they clearly recognized the goals were not achievable without dramatic changes in the performance of their supply base. Among other supplier-related initiatives, they elevated the supplier management function to vice president level, overhauled their approach to forecasting and scheduling, changed the supplier

[5] Details about all Marine Best Practices can be found in the company-specific case studies in the Appendix.

qualification system and went to single sources, and agreed to own supplier in-process inventory for several weeks ahead of scheduled delivery. They were able to apply proper metrics to supplier performance that directly impacted achievement of their goals.

Several instances of similar efforts exist in defense electronics companies. One defense electronics company realized it needed to win a significant Army contract to meet its business goals, and to do that the cost of their offering had to be reduced substantially. This company already was a leader in supply base management practices. They implemented a fundamentally different process for involving their suppliers in the design process. They won the award by reducing the cost of their product by 60 percent, with the reduction largely attributable to the new supplier design participation process. Another defense electronics company decided it had to enter commercial markets to survive the defense drawdown. After thorough benchmarking and analysis, they set a number of very specific supplier-related goals to attain cost competitiveness. The change is continuing, but they have already increased inventory turns by 43 percent, reduced material cost by 25 percent, and reduced the cost of supplier-related problems by 10 percent. Commercial sales have increased to 25 percent of their business and they are on track for 50 percent by 2000.

One of Black and Veatch's corporate goals is to reduce their risk and exposure to claims and liability. To that end, they recognize that suppliers can be very helpful in at least two ways. First, large vendors can assume some of the risk through vehicles like limited partnerships. A second way of reducing risk is through their understanding of their supply base. If a supplier's performance is consistently such that it results in claims, delays, or service issues, then Black and Veatch has the option to either work with that supplier to improve them, or simply stop doing business with them.

Marine Best Practice

The closest we have to a good maritime example is at NASSCO. They have a goal of 95% on time delivery from suppliers. They have used that to drive their current on-time delivery to 88% (we do not have their baseline figures), with 100% on-time from 19 of their top 75 suppliers in May, 1998.

US/Foreign Comparison

The Italian firm Fincantieri is clearly the "poster child" for Supplier Management as a Strategy; no US firm came close to what they were doing. Indeed, Fincantieri is probably comparable to some of the best firms in any industry in the way they have made supply chain management a part of their strategy. However, for most part, the US shipyards seem to recognize the importance of the issue and are in the early stages of taking a more strategic view of the issue. NASSCO appears to be the leader in this, with a more coherent strategy than any other US yard we visited.

Shipyard/Supplier Comparison

Despite the shipyards' emphasis on supply chain management, suppliers did not always see things the same way as did the yards. Suppliers were less likely to see the effects of the strategy the shipyards thought they were following – i.e., while the shipyards said they were following a strategy in which suppliers would increasingly be brought in as partners, suppliers were less

likely to say they thought the yards were following such a strategy. Presumably this is mostly a problem of execution – the yards (particularly the US yards) are in early stages of implementing their strategies, hence suppliers are less likely to see the effects yet. Interestingly, suppliers claim to receive little feedback from the shipyards, even though several yards, including NASSCO, have supplier rating programs in place and say they provide feedback to their suppliers. It may be that these relatively new policies will take longer to filter their way down to suppliers. On the other hand, it may be that the programs are relatively ineffective. Stronger attempts at evaluation on the part of the shipyards could answer this question.

SCM Planning

SCM Planning refers specifically to those activities that are associated with supply chain management. It includes the whole process of planning how to rationalize make-buy decisions as well as planning roles and responsibilities for specific activities for both components and services. In addition, it includes planning the types of relationships the company wants to have with its various types of suppliers. Four Best Practices are included in this section:

1. Core Competency Analysis
2. Increased Supplier Responsibilities
3. Outsourcing Rationalization
4. Strategic Alliances and Long Term Agreements

Core Competency Analysis

When companies analyze and assess core competencies, they do so in order to know whether they have the capabilities which must be maintained internally to provide a unique and defensible position in the market. All other capabilities are considered to be candidates for outsourcing. Strategic make/buy analyses then consider the long term implications of outsourcing candidates. Outsourcing decisions often consider many factors, including: cost of dealing with a supplier, lowest total cost, effect of outsourcing on company overhead allocation, cost of quality and schedule implications, speed to market, surge capacity, acquiring or protecting strategic technologies, and union considerations.

Some companies express concern over the adequacy of methods to assess the long term risk of losing technology that has been outsourced. There is concern that creating substantially expanded capabilities in a supplier through outsourcing may, over time, build that supplier into a new competitor. Concern also exists that, although a competency may not be core, a minimum level of internal knowledge in many outsourced areas is still needed, but may be very difficult to maintain over the long term, and once lost, may be impractical to regain.

The prevailing trend across industry is toward continued aggressive outsourcing. The era of the massive vertically integrated commercial corporation appears to be over in most commercial sectors, but recent mergers and acquisitions have led to increased vertical integration in the defense industry. Most companies simply cannot maintain excellence in every element of design, manufacturing, assembly, marketing, delivery, and service of the complex products of today. There appear to be unresolved issues in how customer firms are managing the shift of competencies and responsibilities from their past vertical operations to suppliers as they themselves become more strategically focused on core competencies.

A large defense manufacturer we know has outsourced almost all of its detailed parts fabrication, including most of its extensive machining operations. They realized that with uncertain or decreasing business, they could realize great cost and facilities savings and effectively manage business fluctuations by having suppliers perform this function. A small producer of defense and commercial electronics products is growing at a rate of about 30 percent annually. They recognized that product design, final assembly and responsiveness to their customers were core competencies, and have outsourced all detail part fabrication and board assembly. Many defense and commercial companies have explicitly recognized supply base management as a core competency. A number of companies have outsourced non-manufacturing activities as a result of core competency analysis, e.g.:

- two companies have outsourced the management of internal tool cribs which not only lowered costs but also reduced the number of cribs from 11 to 7;
- one company has outsourced its security and fire departments; and
- many companies have outsourced the procurement of MRO (Maintenance, Repair and Overhaul) type commodities.

Union considerations are a major factor in these kinds of decisions. The most effective strategies for working with unions is to bring them in as part of the process, so they understand how essential outsourcing is for the survival of the company. In the long run, most unions can be persuaded that it is preferable to save some jobs rather than fight a losing battle to protect all of their jobs. However, in order for this strategy to work, the union must be brought quite closely into the decision making process.

Marine Best Practices

Fincantieri has conducted an explicit analysis of technical competencies which includes a classification by product type and analysis of the people who hold those competencies (e.g., how old are they and will most of them retire soon?). They have focused on design, naval architecture, building the hull, and integration with the customer. Everything else they attempt to give to suppliers. Interestingly, they are struggling with how to keep design in-house – they recognize the need to do so, but now outsource over 40% of their design work. This demonstrates how difficult it can be to maintain a core competence.

Fincantieri recognized when they moved into the cruise ship business that there were essential talents they simply didn't have. Rather than try to build capacity in-house for what may turn out to be an ephemeral market, they rely on suppliers and build long-term relations with them. We should note that this strategy potentially has its downside – firms that work to keep as much work as possible inside maintain greater control over the process and build employee loyalty. For a company whose strategy relies on being extremely agile, working closely with suppliers is essential. Fincantieri has successfully moved in and out of niches in the market (e.g., out of merchant ships and into cruise ships and fast ferries) and feel poised to do it again. In contrast, other shipyards we visited have a relatively stable market, and do not feel the need to be so agile.

Another firm that really stands out as doing this particularly well is Hopeman Brothers Marine Interiors. Hopeman has moved from primarily being a furniture maker to being a company that sees its core competence as program management and system design. They

see themselves (and they make sure customers see them this way as well) as providing turnkey interior systems that they design, procure and construct for the customer. The furniture making operation has been spun off as a separate subsidiary of the parent corporation and indeed, relatively little of the furniture now purchased by Hopeman comes from this subsidiary. Interestingly, as far as we can tell, Hopeman did not do an explicit analysis of "core competencies," but rather arrived at this conclusion as a result of a series of business oriented decisions. Nonetheless, their move in this direction was proactive – indeed, they are perceived as leaders in their industry segment.

Increased Supplier Responsibilities

As companies continue to outsource functions, suppliers are assuming responsibility for an ever increasing variety of operations and services. Suppliers are augmenting their traditional business base with other activities such as program management, product design, assembly and integration, testing, packaging, and shipping. In response to increasing requirements from customers relative to quality and certification, suppliers are also faced with the need to institute different manufacturing and quality practices such as statistical process control.

Suppliers in all sectors are faced with this need to increase their services for their customers. Some suppliers are electing to develop a core competency in these new areas in order to satisfy numerous customers and grow their business. Some suppliers take advantage of this trend to *press their customers* for additional responsibilities.

One commercial company we know, that produces small plastic detail parts for consumer products, has a major customer that wanted them to assemble a very low cost, high volume product for which they supply parts. Although this company had no expertise in high volume assembly, they made a strategic decision to grow their business by accepting the responsibility for assembling not only the portion of the product they manufacture, but also certain subassemblies provided by the customer. The company's goal is to develop a core competency in high volume assembly. They are working with the customer to develop a fully automated assembly operation for this product. They can then apply this assembly expertise to other products and customers, providing a profitable means to perform an operation many customers are striving to outsource.

An important trend in the automotive industry is for suppliers to deliver complete subsystems, for example, completely assembled dashboards or fully assembled suspension systems. This requires suppliers to develop new skills in design, assembly, system integration, and supply base management.

Marine Best Practices

One of the clearest examples of this is Avondale's and NASSCO's use of Hopeman Brothers Marine Interiors as a turnkey supplier for accommodations. In many of their projects Hopeman has complete responsibility for the accommodations as a system. They design the interior, make or source the components, take delivery from their suppliers at the shipyard and perform construction and assembly. Similarly, Cegelec is assuming responsibility for complete propulsion and control systems from design to installation.

Another interesting example of increased responsibility is NASSCO's work with their insulation supplier PCI. PCI is responsible for planning the use of insulation along with

NASSCO staff. This includes how much insulation will go where and how it will be installed. PCI staff then work at the yard to shoot pins[6] on-block while block construction is taking place. After the block is assembled to the ship, PCI then goes back on board to install the actual insulation on the pins.

Fincantieri's subcontractors for public spaces on their cruise ships have a high level of responsibility at the turnkey level.

Outsourcing Rationalization

Some leading companies have matched their outsourcing strategies closely to their long term goals, and to their shorter term business plans and objectives. Such companies have recognized that "one size fits all" does not apply, and have *tailored* their specific outsourcing approach for any given commodity depending for the differences in what is being purchased and from whom. For example, the strategy a company uses with suppliers who have design and manufacturing responsibility for new items should be very different from the one it uses with suppliers of commodity items (like standard integrated circuits) listed in a catalog. Similarly, different strategies would be logical for sole source suppliers versus a number of strong, very competitive suppliers having similar capabilities, or for suppliers who are very large versus small companies. Leading companies have recognized these distinctions, developed approaches reflecting the differences, and related their approaches back to their business strategies, plans, goals and objectives.

Some experts believe outsourcing approaches differ as a function of the relative degree of dependence the two companies have. Distributors of commodity items are not very dependent on any particular customer, nor are any customers particularly dependent on the distributor, since competition is strong. On the other hand, a shipyard and its joiner work supplier are strongly dependent on each other. In the first instance, the relationships need not be close and communications can be infrequent. In the latter case, controlling costs and meeting schedules normally requires a great deal of communication and a relatively close relationship. Very different outsourcing strategies should be expected in recognition of the different relationships that are needed.

One commercial company we know produces home appliances for consumers world-wide. This company divides its suppliers into four categories (Figure 2) and treats each differently.

Strategic	Leveraged
Niche	Commodity

Figure 2. Supplier Categories at a Home Appliance Company

The company recognizes that it is very dependent on the niche suppliers, but not vice versa, and is actively working to remove these suppliers by designing new products in ways that eliminate the need for them. Most defense firms treat their major subsystem suppliers differently from

[6] The pins are several inch long pieces of metal attached to steel plates which hold the actual insulation in place. It is much more efficient to install the pins before the blocks are fully assembled.

other suppliers, and some have carried the differentiation further. One aerospace company distinguishes among three types of suppliers: those having design responsibility; those providing critical materials or processes; and others. In the second category, the company often creates joint technology roadmaps (including company funding of R&D by suppliers) and takes other measures to insure the supplier remains on the leading edge of technology.

As a more detailed example of this practice, John Deere (Deere and Co., 1997) has a sophisticated method for categorizing suppliers that is somewhat similar to the mutual dependence idea discussed above. In Deere's approach, summarized in Table 1, suppliers and their products are grouped according to risk and value.

High	**UNIQUE PRODUCTS**	**CRITICAL PRODUCTS**
	Strategies: Key suppliers design to customer/supplier specifications, provide product/market differentiation	**Strategies**: Strategic Supplier Partnerships, design to customer/supplier specifications, provide product/market differentiation
	Critical Factors: Manufacturing costs high when cost/quality problems occur; difficult to source	**Critical Factors**: Manufacturing costs high when cost and/or quality problems occur; very difficult to source
RISK	**Time Horizon**: Variable	**Time Horizon**: Up to 10 years
	Management Approach: Simultaneous engineering and some "Supplier Partnerships"	**Management Approach**: Supplier Partnerships
	Methods: Reduce # of products & suppliers	**Methods**: Reduce number of suppliers
(source availability, quality, response)	**Agreement**: Contract or Long-Term	**Agreement**: Contract or Long-Term Agreement
	Tactics: Decrease uniqueness of products unless competitive advantage is gained	**Tactics**: Increase role of suppliers
	GENERICS	**COMMODITIES**
	Strategies: Standardize/consolidate	**Strategies**: Leverage/preferred suppliers
	Critical Factors: Cost of acquisition	**Critical Factors**: Cost of materials
	Time Horizon: Up to one year	**Time Horizon**: Up to five years
	Management Approach: Systems contracts/ blanket orders	**Management Approach**: Volume contracting, and some Supplier Partnerships
	Methods: Reduce number of buys	**Methods**: Reduce number of suppliers
	Agreement: Purchase Order or credit card	**Agreement**: Purchase Order or Long-Term
	Tactics: Increase use of technology	**Tactics**: Increase volume with fewer suppliers
Low	**VALUE** (cost, innovation service administration)	High

Table 1. John Deere Supplier Categorization

Note that Deere has considered different types of risk and value. Each of the four resulting categories has different approaches, methods, agreements and tactics that Deere believes are appropriate to the situation in each. The time horizon for the different categories ranges from one year for Generics to 10 years for Critical Products, and the nature of agreements Deere reaches ranges from credit card purchase to long term agreements. Deere clearly has thought through their short and long term business needs and tailored their outsourcing strategy to the different supplier circumstances they face.

Marine Best Practices

Fincantieri has differentiated its suppliers into four different types: strategic (high profit impact, high risk), leverage, bottleneck and non-critical. They have placed the four categories in a matrix of profit impact and supply risk (Figure 3).

The profit impact dimension concerns how much contribution to profit for the whole ship the supplier's product makes. The supply risk dimension concerns the magnitude of risk if the supplier were to fail or perform poorly. Thus, high risk/low profit impact is "bottleneck" because the supplier can hold up production, even though his product doesn't contribute much to the profit in the ship. An example might be paint. The bullets in each cell suggest critical factors for each of the supplier types. For strategic suppliers, they may construct "frame agreements", which are three year agreements that include a fixed price over the period or provide for annual price negotiation. The agreement may include an understanding for ways that costs will be reduced over time or how those reductions will be shared. Leverage and Bottleneck suppliers may have a co-design or partnership arrangement. In contrast, non-critical suppliers are selected using a very traditional bidding process.

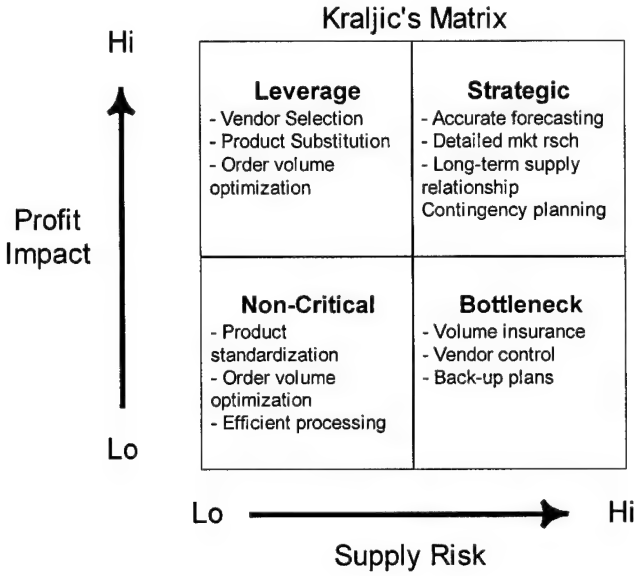

Figure 3. Four Supplier Types

While it has a less elaborate approach, NASSCO works very closely with two suppliers it has formed an informal partnership with, Hopeman for joiner work and PCI for insulation. They also have close, almost partner relationships with eight fabricated outside services (FOS) suppliers, one of which is a NASSCO subsidiary. NASSCO has a more traditional relationship with other suppliers.

Distinguishing between the Fincantieri and NASSCO approaches, we can see that Fincantieri takes a very structured approach to analyzing types of suppliers and working in specific ways with types of suppliers. In contrast, NASSCO has done this with their FOS suppliers, while their other relationships are with specific firms (Hopeman, PCI) rather than types of firms – e.g., they have no relationship with any other joiner work firm.

Strategic Alliances and Long Term Agreements

Strategic Alliances (SAs) and Long Term Agreements (LTAs) are Best Practices seen in many leading companies. These companies pursue long term relationships with their suppliers that can take different forms including strategic alliances, life of program agreements, multi-year (at least 3 years) agreements, etc. Long term relationships are not necessarily appropriate for all suppliers. Strategic alliances should be characterized by key behaviors like mutual marketing or development, or technology transfer between the partners. SAs and LTAs are normally explicitly or tacitly understood agreements that the supplier will get the business if the customer firm does. Such agreements normally remain in place as long as the supplier firm continues to maintain standards of performance appropriate to the business context.

SAs and LTAs provide significant advantages to both parties because of the relatively open sharing of information that normally characterizes such agreements. Customer firms benefit from reduced supply chain management costs and much greater responsiveness by the supplier. Such agreements also often lead to continuous supplier improvement in price, delivery, quality or technology because there is a stronger business and cultural case for supplier assistance and development by the customer firm, or for investment by the supplier. Suppliers benefit from lower costs of sales, ability to reduce costs through better understanding of customers' needs and more accurate information (such as long term business forecasts), and from increased sales. LTAs do not necessarily imply single sources, while SAs usually do.

There is a strong trend in most industry sectors, including defense, for increased use of LTAs. Honda enters into agreements with suppliers with the explicit expectation that the company will remain a Honda supplier forever. Honda of America Manufacturing buys approximately $6B annually from a total of 353 suppliers, and are proud that in 18 years of North American operations they have only "lost" 12 suppliers. Northrop Grumman Electronics and Systems Integration Division has three strategic alliances, including one with M/A COM for key RF/microwave components. Raytheon (TI) has a SA with GEC Marconi for rate sensor gyros. In all these SAs the supplier is expected to stay on the leading edge of its technology. LTAs are too numerous to mention specifically, although it is worth noting that Lockheed Martin, with Government approval, has executed "life of program" agreements with virtually all suppliers to the F-16.

Marine Best Practices

NASSCO has an informal long term strategic alliance with Hopeman Brothers Marine Interiors. As long as NASSCO is satisfied with the relationship, Hopeman has their business for joiner work. Hopeman participates on NASSCO teams to pursue new contracts. From time to time NASSCO will check out the market for joiner work by asking other firms (e.g., Jamestown) to bid on a job. As Hopeman's competitors have learned about the nature of the relationship between NASSCO and Hopeman they have increasingly tended to no-bid on these requests. This presumably limits NASSCO's ability to "check" on Hopeman's prices – requiring a high level of trust in the relationship. So far, the relationship seems to be working well for both sides.

At Fincantieri, suppliers who fall into the strategic category may have what is called a "Frame Agreement." Essentially this is a long-term agreement to provide material for a fixed price over a three year period. The agreement may include an understanding for ways that costs will be reduced over time or how those reductions will be shared. Such

agreements will only be made with large suppliers, such as for steel (although note that the price for steel is fixed annually, in December of each year). A frame agreement need not be exclusive, although it may well be. For example, Fincantieri has a frame agreement with its largest supplier of steel, an Italian steel mill that provides them with 100,000 tons of steel per year. The process of developing frame agreements is also of interest. Fincantieri obtains quotes for a range of products (not for a specific project or bid). They use the quotes to select a number of suppliers and negotiate frame agreements for a specified length of time. It is then relatively easy and quick for Fincantieri to prepare bids using the frame agreement prices. A frame agreement makes it easier to build the schedule since they know who the supplier will be. It also saves the 2-3 months bid time.

Forms of LTAs also exist between engine suppliers and both yards and owners. For example, some owners have preferences for certain types of engines (e.g., MAN B&W Diesels) and will always require them on their ships.

US/Foreign Comparison

Of the shipbuilders that recognize the benefits of planning for supply chain management, only one foreign company (Fincantieri) seems very advanced in this area. It is significantly further ahead in the application of SCM planning than any US shipyard. NASSCO is the most involved US Shipyard. We should note that the other foreign shipyard that we visited (Odense) manages its suppliers very well, but as a matter of philosophy it does not seek to form alliances. In a sense it recognizes the benefits, but prefers to obtain them by vertical expansion rather than partnering. This is due to their culture and unique owner situation. Interestingly, Odense is a leader in international technology development partnerships.

It appears that there are less adversarial relations between foreign shipyards and their suppliers than in the US. Foreign suppliers state that US shipyards provide three or four times the paper in their RFQs, and require more information than foreign shipyards. They suggested that this might reflect that they don't know what they want or that they are looking for ways to legally protect themselves at the expense of their suppliers. As an example, consider that Odense's legal department consists of only one person.

Most US shipyards cite their major customer, the US government, as a constraint as to how far they can develop the Best Practices such as strategic alliances and long term agreements.

Shipyard/Supplier Comparison

Planning for supply chain management is an important function for any manufacturing company regardless of size or position in the supply chain because every company has customers and suppliers. The complexity of the task, and hence the manner in which it is accomplished, will vary considerably with size and position. The percentage of product supplied is roughly the same for all the companies we visited, so the importance of supply chain management could be expected to be similar as well. In general, the shipyards we visited exhibited more Best Practices in planning for supply chain management than did their first tier suppliers. The first tier suppliers tended to take a more *ad hoc* approach to their supply base, and did not seem to have thought through the roles their suppliers might take in helping them to achieve their business goals as well as some of the shipyards have.

Mechanisms

Mechanisms are specific supply chain management practices that are used to work with members of the supply chain. In other words, these are the practices used by the shipyards to implement the plans they have developed which were described in the previous section. In the next section, Systems, we will discuss the infrastructure that needs to be in place to integrate with suppliers. The final section, Activities, discusses the success with which these Mechanisms and Systems are actually used. Nine Best Practices are discussed in this section:

1. Consolidated Purchasing
2. Integrated Customer/Supplier Teams
3. Integration of Suppliers
4. Lowest Total Cost Selection
5. Supplier Continuous Improvement
6. Supplier Training
7. Develop New Suppliers
8. Supplier Managed Inventory
9. Turnkey Suppliers

Consolidated Purchasing

Many companies noted for excellence in supply base management have consolidated the purchasing function. This includes how the purchasing function is consolidated organizationally, and the degree of that consolidation (e.g., plant, single geographical area, business unit, multiple geographical areas, and corporation wide). It includes the company's approach to consolidating its supply base in both numbers of suppliers of like or similar items, as well as consolidating multiple purchases of different items from one supplier into something like a single master purchase agreement. It also includes supply chain-wide purchasing (by either itself or a supplier).

The benefits of consolidated purchasing result from greater internal efficiency of the purchasing function itself, greater purchased volume from a given supplier, and enabling much closer relationships and more open, honest communication with suppliers. Consolidating the number of suppliers normally reduces the internal cost of purchasing. Integrated packages and greater volume both can result in fewer purchase orders, lower prices, better delivery performance and better supplier responsiveness to customer needs. Closer relationships and strong communications are a critical element of many other advanced practices, but it is very difficult to do with large numbers of suppliers that change frequently.

There are many different forms of advanced consolidated purchasing that companies have evolved to meet their different business contexts. Several examples from different industries will illustrate. As an example of classic consolidation of the purchasing function, Lockheed Martin has consolidated Purchasing for its three military aircraft production facilities into one Advanced Material Management Center in Fort Worth, and expects to save $410M in internal costs alone over four years. Another example is where one firm buys all material for its entire supply chain. Honda, for example, buys all steel used by its suppliers. A very small (less than 200 employees)

telecommunications company has outsourced all circuit board fabrication and assembly, but executes annual master agreements with an electronic component distributor that all its suppliers order against. One commercial electronics equipment producer has consolidated purchasing with nine separate companies that are owned by a parent holding company, and is investigating doing same with several of its large customer firms.

Marine Best Practices

Fincantieri reported a form of this practice in the European Share International Purchasing (EURO SH.I.P.), which started in 1991. There were four shipyards involved: AESA (Spain), CDA (France), HDW (Germany) and Fincantieri. The teams from the shipyards would meet monthly and share what they felt were competitive prices for a range of equipment as well as best technical aspects (design and specifications). They would then invite suppliers to propose frame pricing agreements for the whole group. Suppliers would make a firm pricing commitment giving the shipbuilding group the right to accept or reject. Average cost reductions in 1997 were:

Steel Profiles	*12%*	*Steel Pipe*	*13%*
Electric cable	*17%*	*Anchors & Chain*	*4.5%*

Customer/Supplier Teams

Customer/supplier teams are frequently employed by leading firms to solve problems, develop designs, eliminate waste, create joint technology roadmaps, etc. One of the best known examples of this is Chrysler's Platform Teams. At Chrysler, a Platform Team is responsible for the development and ongoing change for a whole series of cars – e.g., Chrysler's Large Car Platform Team is responsible for the LH series of large cars (Chrysler LHS, 300M and Concorde, and Dodge Intrepid) and the "cloud" mid-sized cars (Chrysler Cirrus, Dodge Stratus, and Plymouth Breeze). The Platform Team is co-located at a single location at the Chrysler Technical Center and includes all engineering functions, as well as representatives from purchasing, finance, and manufacturing. Also co-located with the Platform Team are representatives from suppliers of all major subsystems, such as instrument panels, seats, suspension, fuel system, etc. These supplier representatives are treated just like Chrysler employees, being provided with badges for entry, work space, computer access, etc.

Rockwell Collins has commodity teams focused on technology sets such as displays, oscillators, ASICs, etc. One of their assigned tasks is to create and maintain technology roadmaps, which they do by adding the appropriate suppliers to the teams for that purpose. Several defense and mixed defense/commercial production teams routinely practice team-based continuous improvement events. However, supplier development is much more widely practiced by leading commercial companies than it is in the defense environment, and long term integrated teams have not been observed in defense.

Teams can also be used to improve processes. An example of such an activity is the process-focused *kaizen* events done routinely with even the most highly rated suppliers. Kaizen events typically address a focused process or small group of processes with an integrated team, and analyze the situation, develop an improvement, and implement it, all in less than five working days. A version focuses on a supplier product, usually a mature product, and develops a multitude of small product and processes changes that in aggregate reduce the product cost or

improve its quality. The team then calculates the new supplier price and specifies the design changes the customer will make, all within a week. Integrated teams also work together intermittently over a long period to make major improvements in broader areas, such as the supplier's quality system. In some cases, customer firms will send an expert to live with the supplier for several months to become a full-time member of a supplier team formed to make improvements or solve problems.

The customer firms who practice teaming with suppliers firmly believe they pay off in significant improvements to supplier prices, quality and/or delivery performance. However, a major drawback is that all except product changes and specific problem solving are not amenable to calculating immediate benefits. Their effects are cumulative, and the practitioners believe they are responsible for improved supplier performance over time. For example, a single kaizen event to take waste out of a single process is not likely to result in large enough savings to impact the bottom line product price, but a number of them will.

Marine Best Practices

The most explicit example of customer/supplier teaming we saw was the use of Integrated Product Teams (IPT) at Avondale for the LPD17 design and construction. Based on a Navy requirement to use IPTs on the LPD17 program, Avondale formed a team consisting of Intergraph for information systems, Bath for design and construction, and Hughes as the systems integrator for all systems (what Avondale calls a "system of systems"). These companies are viewed as partners, and their portion of the effort was not competed after award. The proposal was structured around what Hughes could do as the turnkey systems supplier with total design responsibility. It appears that this process will be used to develop a new cruise ship proposal, and even expanded to include some suppliers donating time to build specifications for items of the type they supply, even though these will be competed after award. Hopeman Brothers is performing the joiner work on the LPD 17 program. They joined the IPT after a competition through an RFQ and are a member of the alliance, even though they were not in from the start. Hopeman now participates as a full member of the IPT. The LPD17 IPTs include all appropriate Avondale disciplines (including buyers), the Navy and DCMA. Team member personnel attend IPT meetings, vote on matters under their cognizance, and offer ideas for constructive change. The use of IPTs is new to Avondale and the change has been accompanied by considerable learning about the need for efficient team decision-making. IPTs have strong top management support and are considered to be the way things will be done on future programs.

Integration of Suppliers

Companies regarded as excellent in supply base management tend to treat their non-commodity suppliers and themselves as a single business entity, and sometimes commodity suppliers are included as well. Many of these firms view their business context as themselves and their suppliers competing against other extended enterprises. This attitude is not a matter of rhetoric; it is manifested in a combination of many different aspects such as attitudes toward suppliers, the suppliers' involvement in product development, the nature of relationships that exist, and the degree of schedule integration in production, to name just a few.

The attitude that suppliers are an integral part of the customer firm's operations, especially when coupled to an understanding of the importance of suppliers in achieving corporate goals, is an important enabler of a number of other Best Practices. For example, it can strongly influence the content of technology, business and product development plans, as well as the processes by which they are created. It especially influences the nature of communications with suppliers and the level of trust existing between customer and supplier. The attitude that supply chains are competing is especially powerful in influencing adoption of this attitude. An important benefit of this philosophy is that it affects how the customer company looks at who should have responsibility for what. When the entire chain is viewed as an entity, it makes it much easier to move work to where it can be done most efficiently and effectively.

A number of commercial firms have this attitude, as do some defense firms. Honda developed it back in the 1950s when first starting in the motorcycle business -- they needed the help of suppliers, recognized that everyone was in the venture together, and understood that operating as a single enterprise was the best hope for success. Chrysler has this attitude, and found it greatly facilitated supplier participation in design. As an example of the benefits, Lamb Technicon, a supplier of assembly systems, was participating on the Neon design team with responsibility for designing the assembly system. They suggested design changes to the car that eliminated an entire line and saved Chrysler about $50M in capital costs. Rockwell Collins has adopted this attitude and carried it to the point where suppliers participate on their internal commodity teams. These teams are responsible for sourcing strategies and technology roadmaps, among other things, and the suppliers participate as equal members. The company regards supplier participation as critical to maintaining leading edge technology capabilities in their products. One commercial supplier to whom process control is particularly critical has implemented procedures whereby customer firms can query the SPC system on every machine in their plant any time 24 hours per day. The supplier is noted for its outstanding quality performance.

Marine Best Practices

NASSCO has very tight integration with two suppliers, specifically Hopeman Bothers and PCI. In the production areas Hopeman and PCI are treated as "another NASSCO trade" rather than as a separate supplier. Their work is scheduled by NASSCO's scheduling system, which has significantly reduced problems. They also attend bi-monthly status meetings, receive progress payments, and attend NASSCO planning meetings. NASSCO is bringing other suppliers into this mode of operation. MacGregor supplies Sealift doors and ramps and is well integrated into NASSCO's outfitting operation. NASSCO is also trying to bring Sperry to the same level of integration as Hopeman and PCI. NASSCO believes the key enablers of supplier integration are increased and more effective communication, and fewer suppliers.

Fincantieri also does this very well, integrating its major space outfitters into its tactical level of scheduling. They do not appear to have achieved the level of detail in integration done by NASSCO, although they are doing it with a much larger number of suppliers. This may be due to the large number of suppliers they have on-board during the later stages of construction – e.g., they have as many as 1500 vendor employees working on-board a cruise ship (out of 3000 total) as last minute details are being completed.

Lowest Total Cost Selection

Many companies select suppliers based on lowest total cost rather than lowest purchase price. Some companies have a clear process for implementing the concept that considers their own internal costs in detail and is done routinely with most of their supply bases. The lowest total cost idea is that everything involved in supplier selection and management, in receipt and installation of the supplier's product, and support of the end item after delivery that involves the supplier's product represents a cost that should be added to the supplier's product cost to arrive at the total cost associated with that supplier. Competing suppliers are ranked on the basis of *total* cost, and the one showing the lowest total is selected. Sometimes the term "Best Value" is used for this practice, but many prefer lowest total cost because in has more quantitative connotations.

Supplier quality is a key element. Some companies measure quality performance such as numbers of defects by assessing the economic cost to the company, depending not only on the severity of the problem, but also on the when the problem is discovered. In such schemes, problems found before assembly are weighted lowest, problems found upon assembly are weighted considerably more, and problems found by the ultimate customer are weighted severely. Suppliers' delivery performance is also a strong cost driver and is ranked by some companies and included along with quality rankings. Suppliers' bids are multiplied by the factors. Other companies calculate a dollar value associated with the number and different types of defects, and add that to the bid price. Other companies take a simpler approach of understanding that quality costs them significantly, and select the supplier with the best quality record provided his bid price does not seem out of line. To be effective, all such approaches require detailed records of supplier quality performance.

A number of defense and commercial companies use this practice. One commercial supplier will only do business with *customers* who select on the basis of lowest total cost, and has a strong advocacy argument for the practice. For the 11 years since employing this strategy, their sales have increased more the 20 percent each year. One defense producer measures the quality and time of deliveries. Costs are assigned to late deliveries, rejections at receiving inspection, and rejections in assembly. The suppliers are indexed and rated accordingly. Future selections are made based on this data, and suppliers are automatically deleted from their Approved Supplier List when they fall below two standard deviations from the norm.

A leading supplier of aerospace equipment to airframe and engine companies follows a very similar approach, but they have a more complex quality performance rating formula. The formula combines four separate calculations regarding the results of receiving inspection, purge and assembly, source inspection and field reports, and adds a factor for supplier requests. The result is combined with delivery performance to arrive at a Total Quality Price factor that is multiplied by the bid price.

The Competition in Contracting Act (CICA) and Government approval are often cited as barriers to doing this in government work. They are not absolute barriers, but they can represent significant impediments. Local interpretations vary considerably, making approval of lowest total cost suppliers much more difficult for some companies than for others. Nevertheless, defense companies willing to put the justification documentation together seem to have little difficulty implementing this practice. However, it is always easier for buyers to simply select the lowest price supplier than to create the documentation needed to select the lowest total cost supplier.

Marine Best Practices

Hopeman is also pursuing this strategy, and they believe they see a trend for greater acceptance of the concept by their customers. Hopeman and Cegelec sometimes see the ship owner as their customer. In this case, they are selling best overall cost for operations as well as first cost. The owner then specifies the vendor and the shipyard has little or no choice.

Supplier Continuous Improvement

A number of leading commercial firms demand and realize continuous improvement in cost, quality and delivery by suppliers. Most companies have some form of targets for cost, quality and delivery, but those companies that insist on a more or less formal continuous improvement effort by the supplier appear to realize greater performance benefits. The relative emphasis on the three metrics varies, most often depending on specific competitive factors and maturity of the technology involved in the supplier's product.

Cost control/reduction targets are often negotiated, especially where long term agreements are involved. Some companies have specific annual price reduction targets for all suppliers that are the same, while others vary the price reduction targets depending on the specifics of the company or product. Some firms demand a strong continuous improvement program, backed by top level management commitment, as a condition for preferred or single source supplier status. The customer firm may play a strong role in working directly with suppliers through training and other types of supplier development, or it may have little direct involvement other than assuring key suppliers have such a program and tracking the results. Insistence on strong supplier continuous improvement appears to require the same philosophy within the customer firm.

Demand for supplier continuous improvement appears to be a significant trend in many commercial sectors, but it is rarely seen in the defense environment. Many commercial companies require annual cost reductions, and some also include delivery improvements. For example, Honda has a four year production run for its models, and suppliers agree to a 4% price reduction the first year, followed by 2% each year thereafter. On-time delivery rate is 99.78%.

Defense companies seem to concentrate on negotiating an initial price and trying to hold to that price in future negotiations. One company who produces for both military and commercial customers requires its suppliers to meet price and price reduction targets. This company accepts a responsibility to assist suppliers to achieve those targets and discharges that responsibility through a variety of mechanisms including changes to designs, specifications, flowdown requirements, etc. that reduce supplier costs. Purchasing agreements for new production include price reduction targets that vary with different parts or products -- there is no set formula. For example, a reduction target might be 15 percent in one year, or it might be three percent per year for five years.

Marine Best Practices

No examples of this practice were noted in the shipbuilding industry, but the practice is applicable to the industry, at least in principle. The low volume of domestic shipbuilding appears to be a barrier to broad use of this practice, since the shipbuilding business is normally a very small percentage of the suppliers' sales. However, there may be certain supplied items where the purchase volume is sufficient, and the practice would be more

applicable were the industry to adopt supply base consolidation and more long term agreement practices. For example, multiple buys negotiated up front for potential follow-on orders might result in lower unit cost.

Supplier Training

Many world class commercial companies pursue aggressive, continuing activities with their suppliers to help them improve in any and all areas of their business. A key element is training. Such companies often offer training to their suppliers in many areas including business and management as well as technical topics, and will make such training available on a continuing basis to most suppliers at no charge or for certain administrative expenses such as travel costs, training materials, etc. The suppliers normally are free to use their improved capabilities for other customers. Some companies have organized supplier conferences, primarily for the purpose of providing a structure for suppliers to learn from each other.

Small suppliers rarely possess the capabilities possessed by their larger counterparts. The primary reasons for this capability gap between smaller and larger companies appear to be lack of financial and technical resources. Customer-provided training can be extremely valuable to the smaller suppliers. Some companies regarded as excellent in supply base management will provide training in any topic the supplier needs, normally using their own training personnel. Suppliers can be required to take training in topics when needed to support new customer initiatives. For example, General Electric has a widely publicized corporate-wide quality initiative, and is requiring suppliers to be trained in statistical methods and statistical process control in order to reach the corporate goals of six-sigma quality. John Deere has a very active training program in supply base management because of the importance of the topic. They offer identical training to Deere and supplier purchasing personnel. In 1997, they trained about 8,000 people at a cost of about $3M.

Excellent commercial companies tend to offer a wide range of training. Honda has 353 suppliers, and 192 have received some form of training from Honda. For new suppliers, all Honda training is free; after that they must pay for supplies and travel. They break the kinds of training into the following categories: employee involvement programs, management, maintenance, environmental and safety, specialized skills, and administrative. In 1995 for example, Honda trained 1152 supplier personnel in the following types: 550 management, 19 facilitator, 281 quality control seminar, 135 five principles of problem solving, 87 quality control tools, and 80 presentation training. Honda wants suppliers to offer training to their own suppliers, but will train second tier suppliers themselves upon request.

Defense companies tend to offer a more limited range of training with a heavy focus on quality. Some defense companies only offer SPC training. Some defense companies offer no training at all, but most offer some. One mixed defense and commercial producer offers a wide range of training on technical topics, including SPC, statistical methods, the product development process, problem solving techniques, process and product improvement techniques, and specific aspects of metallurgy. In addition, they have identified and published a list of domain experts throughout the company which suppliers are free to call on at any time. They also have prepared a number of process templates that contain information on how to perform the processes, equipment and facility requirements, etc. These are available to suppliers at no cost.

Marine Best Practices

In the only examples seen in shipbuilding, Fincantieri offers CAD training to suppliers, and Odense has one person whose full time job is to work with and train suppliers to improve their quality processes. As with Supplier Continuous Improvement, the applicability of this practice in shipbuilding may be limited to special topics and a restricted number of suppliers because of low volumes and very low business percentage with many suppliers. An issue here is that the shipyards are often not the technology leaders. Cegelec said they spend a lot of time educating the shipyard. Similarly, Hopeman tries to educate the yard to improvements in Hopeman's practices.

Develop New Suppliers

If a suitable supplier is not available a company may want to help create a new company or help an existing company develop a capability to act as a supplier to them. Perhaps the best known example of this mechanism is when the Japanese "transplant" automakers (Nissan, Toyota and Honda) came to the US. At first they established assembly plants that imported almost all of their components. They imported so much because existing US automotive suppliers were unable or unwilling to meet the Japanese requirements for either quality or product features. So they imported what they needed from existing suppliers in Japan and elsewhere. Wanting suppliers closer to the assembly plant, they first induced some of their existing supplier to locate operations in the US, nearby to the assembly plants. However, they also had a stream of US suppliers who wanted to sell to them, but couldn't meet their requirements. So, they worked with these potential suppliers to help bring their products and processes up to meet their requirements. This assistance consisted of training and on-site consulting services provided directly by the automotive OEM, as well as assistance in finding other forms of help from outside consultants. For example, Toyota set up the Toyota Supplier Assistance Center which assists both current suppliers and potential suppliers. Toyota (and Honda) does this in full recognition that other OEMs are likely to use the same supplier and hence gain some benefit from their efforts (and expense). Their response to such concerns is that they (Toyota or Honda) will gain more than the competitor because the supplier has learned their system rather than their competitors' – hence there will always be greater compatibility and a closer relationship. So, while the competitor will gain something, the company that does the developing will gain even more.

Marine Best Practices

Fincantieri recently linked up a furniture maker with a wall maker to have them jointly provide integrated, whole cabins. Thus, they are attempting to modify the structure of the sub-supplier sector. But, finding companies that can act in this role is difficult. As another example, they encouraged suppliers for ramps on their RoRo ships to provide turnkey ramps and achieved a 35% savings as a result. They also set up a new company to fabricate structural beams for all Fincantieri shipyards.

Roughly 75 percent of NASSCO's FOS (Fabricated Outside Supply) business is with IMT, a NASSCO-owned subsidiary whose manufacturing facility is just across the border near Mexicali, Mexico. NASSCO has cultivated an interesting relationship with IMT. Whereas most FOS suppliers build to NASSCO-supplied drawings, they have helped IMT develop a CAD capability, and IMT now provides design services and CAD lofting.

NASSCO and IMT have weekly home-and-home status meetings. The IMT Quality Assurance Manager visits NASSCO weekly. IMT produces a variety of "Q parts", which are miscellaneous standard items. NASSCO production people fill out a kanban card based on previously-set minimum order quantities, and directly issue the work order to IMT. In another case, NASSCO needed a source for special pipe fittings. They approached a company, Victualic, who made similar products but did not sell to the marine industry. NASSCO helped the supplier qualify pipe connectors for marine use, and the supplier now advertises and sells a marine line.

Much like NASSCO, Odense has developed new suppliers in low cost countries, in their case in the Baltic states of Estonia and Lithuania. As with NASSCO, the suppliers are wholly owned subsidiaries. The are also encouraging their traditional suppliers to do the same, e.g., encouraging ABB to set up a subsidiary in Lithuania to support Odense's Baltic operations.

Supplier Managed Inventory

A supplier manages inventory when the supplier is responsible for making sure that the customer's inventory is kept up to certain minimal levels without individual orders from the customer. One of the most well known examples of this is in the local grocery store. For many product lines (e.g. soft drinks, bread, snack foods and many others) a vendor's representative is responsible to make sure that the store's shelves are properly stocked. This can be managed by regular visits from the representative (often the case with groceries) or, as is more widespread in manufacturing, through the use of a *kanban* like system where orders are automatically sent when minimum inventory amounts are reached. Vendors are then responsible to make sure the right parts get where they are needed.

A significant number of companies in several industry sectors have realized that inventory management is not among their core competencies and have asked their suppliers to assume that responsibility. The companies that employ supplier-managed inventory anticipate cost savings in implementing these techniques. The suppliers also benefit from this practice. Tighter coupling with the customer, the opportunity to expand the business relationship, and the ability to stabilize production through better access to real-time statistics are just of few of the benefits.

One company we know sees supplier-managed inventory as integral to their strategy to focus on customer service and responsiveness. Most of their MRO (Maintenance, Repair and Overhaul) items, standard production parts and some machined parts are now "managed" by the suppliers themselves. This practice has not only helped the company reduce costs, but should help them weather a market down turn through reduced inventory cost exposure.

Marine Best Practices

All the shipyards we visited have some level of this for consumables, such as fasteners and welding supply. As an example, NASSCO has a supplier-managed inventory for high-use items such as Nelson hangers and fasteners. Suppliers roam the facility keeping bins stocked on a min/max basis. In some instances, a supplier will produce an entire shipset of items where there are sufficient efficiencies. The supplier will produce the items, have them source inspected, be paid for the entire production run, hold the

inventory, and deliver them incrementally as needed. Hopeman and PCI are responsible for managing their own inventory within NASSCO's facility..

Turnkey Suppliers

A turnkey supplier is one who provides a complete system based only on a set of requirements from the customer. The supplier designs and builds the system and installs it where it is supposed to work. Use of this approach is widespread. For example, manufacturing systems suppliers to the automotive industry are often responsible for a whole system such as one that assembles door panels or whole car bodies. These complex systems are assembled out of multiple machines with complex software coordinating the whole operation. The supplier of such systems is typically responsible for finding out what the automotive OEM wants to build, for designing and constructing the system, and for installing and proving it out on the factory floor. Until it builds good parts the system belongs to the supplier. The automotive industry is moving toward having suppliers provide turnkey automotive subsystems as well. In several experiments in Brazil by Volkswagen, GM and Ford, supplier personnel install automotive subsystems on cars as they move down the assembly line. GM has announced plans to take a similar approach in their new assembly plants in the US.

Marine Best Practices

Both Avondale and NASSCO work closely with their joiner work subcontractors (like Hopeman and Jamestown) and at least some of their power and electrical controls subcontractors (especially Cegelec and Hughes) who provide them with turnkey systems. Best practice appears to be to define systems that are as large as possible and to find a supplier who can provide that system on a turnkey basis. However, this only works in instances when there is a close working relationship between the supplier and the shipyard. NASSCO accomplishes it for their turnkey joiner work by the integration of their design managers with Hopeman designers.

Fincantieri uses a substantial number of turnkey suppliers, and they are trying to develop additional suppliers who can provide such systems. For example, they have turnkey suppliers who are responsible for the galley or for a theater on a cruise ship. Typically the supplier is not responsible for all of the accommodations, while NASSCO would probably have their supplier responsible for all of the accommodation area. However, the greater complexity of a cruise ship accommodation means that there are few if any suppliers who could handle the level of work required to do it all.

US/Foreign Comparison

For the mechanisms category as a whole the comparison between US and foreign firms is a mixed story. There seems to be more consolidated purchasing by foreign yards, although that may just be on an experimental basis. Foreign yards seem to have a somewhat better overall quality of relationship with suppliers, but there are certainly many examples of very close relations in the US. Foreign yards seemed to be doing more to train their suppliers, and with the exception of NASSCO, more to develop new suppliers as well.

US yards that were interested in building the American Classic cruise ships[7] (Avondale and NASSCO from our sample of firms) formed alliances with the joiner work companies. In this particular case, the yards were relying on the experience and relationships of their suppliers. This is different from the relationship in the construction of a tanker or container ship. Therefore, the relationship with the suppliers may be dependent on the type of vessel. This observation is best illustrated in Odense, where the type of vessel has a large steel component of work and relatively small outfitting. Contrast this to Fincantieri which is building a very complexly outfitted vessel and as a result relies heavily on their joiner subcontractors. Fincantieri appears to be increasingly moving toward greater use of turnkey subcontractors in the future.

There appears to be several efforts in Europe to establish multi-shipyard purchasing relationships that are not found in the US and in some versions may not be legal here. These might be viewed by U.S. suppliers purely as a means to beat down their prices, rather than as a constructive approach that can have benefits for both shipyards and suppliers.

Shipyard/Supplier Comparison

US shipyards are driven by the need to arrive at a US competitive cost. The contracting process that has evolved in the US is specification-based. That means that a detailed set of specifications is either provided to the shipyard by the vessel owner or prepared by the shipyard for the shipowner. Eventually a Contract Specification is negotiated and the contract awarded. This set of specifications is then used by the shipyard engineers to develop purchase technical specifications (PTS) which are sent to the suppliers for review and bid. The drive toward the lowest possible price has driven a contentious purchasing and negotiation process in which some of the technical and schedule, and all of the cost risk are forced upon the suppliers.

Some of the suppliers (such as major equipment manufacturers) we interviewed had attempted to circumvent this process of being beaten down to lowest price by dealing directly with the vessel owner during the conceptualization and preliminary design of the vessel. The suppliers in fact worked on the product design of their sub-systems for the vessel. In this case, ultimately, the suppliers ended up writing the specifications which the shipyards then send out for bid. However, unless the supplier can get the vessel owner to purchase their equipment directly and provide it to the shipbuilder as Owner Furnished Equipment, the supplier still has to bid competitively the system they designed (specified) with other suppliers. However, many suppliers are willing to take this risk as they believe their better knowledge of the system; the fact that it was designed around their equipment, should give them a competitive advantage.

Systems

What we call "systems" includes the business processes, organization, culture, and technology in both the customer and supplier that serves as the environment in which mechanisms are used. Some of these are not easily, if at all changeable (national culture is the best example); all are harder to change than the other non-systems Best Practices discussed in this report. We will not discuss any systems that can't be changed in some reasonable manner. Three Best Practices will be discussed in this section:

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[7] As this report was being prepared it was reported that Ingalls had won the competition for the these ships. The experience of the firms in our sample in this regard is still relevant.

1. Integrated Product Data Systems
2. Integration with Customer Planning and Scheduling
3. Organizing for Coordination

Integrated Product Data Systems

In the best manufacturing companies worldwide product data flows easily (or at least relatively easily) and in a timely manner between functions in the company and between the company and its suppliers. While the "within the company" part might seem irrelevant to a report on supply chains, the simple fact is that until a company is able to make data flow smoothly internally, they can do little about data flow in the supply chain.

Both Chrysler and Boeing have determined that they will use a single product model for their products. For them, CATIA serves that purpose – all designers within the company use the same CAD system. All suppliers are also expected to use CATIA. This supposedly solves the problem, but in fact it does not (AIAG, 1998a). While many Chrysler and Boeing suppliers do indeed use CATIA as their main CAD system, many also do work with other customers who use other CAD systems. Still others find that CATIA simply does not meet their needs for efficiently doing the types of design work they need to do. Thus, there are many Chrysler and Boeing suppliers who do not use CATIA as their system of choice for design. Instead they do their design work on another system and translate to CATIA when it comes time to move data to Chrysler or Boeing. This is usually not too serious a problem – the translation process takes only a small amount of time and adds little cost when it goes well, but of course it does not always go well – errors may be introduced or the model may translate incompletely. If these problems go undiscovered until after the data is exchanged (either way) the costs could get very large.

Chrysler and Boeing both have several systems for exchanging data with suppliers. The most commonly used is a mailbox system in which files are exchanged using email over a private network. Some files are exchanged over the Internet. The automotive industry is currently developing a proprietary Internet-like system called ANX, which will effectively be a secure intranet for the automotive industry.

Neither Chrysler nor Boeing describes any difficulty getting product data out of their suppliers. This is not surprising, given the quantity of business they generate for their suppliers. Suppliers in both automotive and aerospace on the other hand, do complain that it is often difficult to get needed product data from their customers. The problem is usually some bureaucratic release issue. However, when the supplier explains the urgency of his need to his counterpart at the OEM, the data in some form is usually on its way fairly quickly. In other words, when there is an understanding of the urgency of need, response is fast. It is also worth noting that in both the automotive and aerospace industries schedule is king – things are moving so fast during any design process, and so many things are tightly integrated, that for anyone in the design area to miss a deadline is a hanging offence – you just don't do it. This is especially true at Chrysler, which has the shortest design to production cycle of any US automaker, and one of the shortest in the world.

Looking at another industry, construction, Black and Veatch also has urgent needs to exchange data with suppliers. Internally, they have a highly integrated system focused on their Powertrak database system, which links data from more than 60 different applications. However, suppliers

are not linked into Powertrak. B&V describes many more problems getting vendor furnished information (VFI) from suppliers that do Chrysler or Boeing, but it seems to be much less of a problem than it is for most shipbuilders. Their most effective tool for getting the information is to communicate the urgency of their need to the supplier. This requires that the need actually be urgent, that the project be at risk of going off schedule if the information is not received in a timely manner. B&V appears to be quite good at keeping to its schedule and communicating that to suppliers – hence suppliers are relatively responsive with providing information as needed. B&V calls out VFI as a deliverable for suppliers and also charges suppliers for liquidated damages when they don't deliver.

Marine Best Practices

Although all shipyards and most suppliers use CAD for design purposes, most product data exchange is with hard copy drawings. One exception is Fincantieri, which does a significant amount of CAD file exchange with some suppliers. Most, if not all, of those suppliers use the same CAD systems as Fincantieri, but they are essentially captive suppliers who do little if any work for other companies.

Both Odense and Fincantieri claim to have little difficulty getting VFI from suppliers in a timely manner. We suspect this may be due to their high degree of leverage with many of their suppliers. Odense reports that as much as 10% of their VFI is late, but that it typically does not affect schedule or cost. Odense charges a 5% penalty per week for late drawings.

NASSCO is making a serious attempt to improve their receipt of VFI, but since the effort is so new we have no information on how successful it will be. They are explicitly listing VFI requirements in an Attachment to the contract and they are building a computerized system to track compliance with these requirements. They are also attempting to make VFI part of the bid process, although this is not always possible if designs are part of what is being bid. NASSCO believes more frequent communication that results from email between cognizant engineers and suppliers will help as well.

Integration with Customer Planning and Scheduling

As suppliers get more tightly integrated with the activities of their customers, integration of schedules becomes critical. At Chrysler for example, suppliers operate according to various schedules released by Chrysler. On the design side, Chrysler has a series of prototype deadlines at which full vehicle prototypes will be tested. If a supplier's component is not ready for that test then the whole prototype schedule is thrown off. Since top executives are usually involved for such tests, the consequences are very grave. So, suppliers take Chrysler's schedule very seriously. Equally, on the production side, in a mass production environment delivery just-in-time (JIT) is critical. For example, seat suppliers to Chrysler (and other automakers) deliver fully assembled seats every two hours. The seats are delivered and loaded directly onto the production line in the order in which the cars will be assembled. This requires a very high level of information integration. This high level of integration is probably not required in the shipbuilding industry. Nonetheless, some level of JIT is probably essential, less for reducing inventory costs than for putting a process in place that forces the yard to focus on its schedule and suppliers to keep that schedule in mind while focusing on quality.

Some shipyards define JIT as receiving material on schedule. None that we know of plan to receive material less than days before needed and some believe that two weeks before use would be fine. However, not receiving material or equipment when it is required is at least as big a problem for them as late delivery in the other industries, if not worse.

At NASSCO the supplier schedule is integrated into NASSCO's schedule. This was the tightest level of integration we have seen. Fincantieri suppliers were represented on their schedule. Suppliers had the opportunity to have input to Fincantieri's schedule.

Organization for Coordination

A company develops a type of organization for product development in order to control the process and to provide sufficient coordination mechanisms between different functions. In terms of supply chain management, a primary concern is that engineering has sufficient coordination with suppliers or customers. This coordination can be provided by project management or it can be provided by process, as just two examples. However, it must be provided – we have often seen examples where coordination with suppliers during product development just doesn't happen because "it's nobody's job."

One of the best known examples of doing this well was Chrysler's reorganization into "platform teams" in 1989 (Fleischer and Liker, 1997). In effect, Chrysler established permanent cross-functional IPTs for whole product lines. A platform team covers each major "platform" they produce: minivans, large cars (e.g., LH), small cars (e.g., Neon), and Jeep/Truck (Jeeps and pickup trucks). A team consists of all the engineering disciplines, permanent representatives from manufacturing engineering, and part-time representatives from finance and purchasing. At their peak, about two years before launch, these teams have as many as 800 people, all located in a single area in the Chrysler Technical Center. In addition to Chrysler personnel, representatives from all major suppliers sit with the team and have full access to the building. They look and act like Chrysler employees.

The platform team would be much less effective if it were only an IPT with suppliers sitting on it. They've put a whole package together – computer systems, physical co-location, formal reporting structure, and a common set of goals, so that the team works as a single entity within Chrysler, that *incidentally* has suppliers as members of the team. Chrysler's process is far from perfect. It now seems clear that one of the problems is that suppliers have taken over so many roles that the company may be losing the skill to manage their suppliers effectively.

Toyota uses a very different approach from that used by Chrysler (Sobek, Liker and Ward, 1998). Rather than relying on cross-functional teams, Toyota has maintained a strong functional structure (by engineering disciplines) with coordination provided by two key mechanisms: powerful vehicle-level chief engineers and strong standards for both product and design process that are constantly evolving as new learning develops. Toyota suppliers often have a "guest engineer" co-located at Toyota. They will tend to work with their appropriate engineering discipline, rather than with any sort of cross-functional team.

Which of these models is better in an American context? Most observers believe the Toyota approach, which evolved over decades in the post-WWII environment would be very difficult to emulate in the US (because we are not under the same level of crisis as the Japanese after their defeat at the end of the war). However, aspects of it are clearly worth moving toward. For

example, it seems clear that stronger, more technically qualified chief engineers would be helpful in any product development process. But, people to fill these roles must be developed purposely, a process that can take 10-20 years.

Marine Best Practices

We saw no evidence of innovative organizational systems at the shipyards we visited. For the most part, shipyards seem to have maintained their functional divisions, using relatively weak project managers and informal communication as the primary coordinating mechanisms between functions.

US/Foreign Comparison

Both foreign shipyards we visited claim to have little difficulty with VFI, while all US shipyards find it to be a persistent and serious problem. From the information we have, we believe we can attribute this to two factors. The first is how closely the shipyards adhere to schedule; the second is how much leverage the shipyard has on its suppliers. In terms of schedule, the consistent message seems to be that if you stick to your schedule and let your suppliers know that, then they will be much more likely to do the same, including their delivery of VFI. Foreign shipyards seem much better than US yards at keeping to their schedule, and suppliers know this. In terms of leverage, both foreign shipyards have much more leverage than any of the US shipyards have with most of their suppliers. We note that for those suppliers where there is leverage, the VFI problem is much less – NASSCO has no problem with VFI in their relationship with Hopeman for example.

Americans tend to prefer a great level of detail in agreements, whereas Europeans are more comfortable with a degree of ambiguity that allows flexibility. Related to the above, foreign shipyards and suppliers have developed a fear of landing in court due to the generally litigious nature of the US. In Europe, disagreements are much more likely to be resolved amicably between the parties, and without the hassle and costs of a court fight. Claims and litigation are built into the US way of doing business. To some extent, this is because of the "low-bid" focus by their government customer, and this carries over to the low-bid competition between US yards. One European supplier was taken aback by the political nature of the shipbuilding work in the US. They feel that competition on the basis of product quality, price/performance, etc. is skewed by the political nature of the market rather than economic rationalism.

In planning large projects, there are appropriate levels of time horizon and variance for each level of management. By breaking a complex project down and delegating responsibility and control to lower levels of management, effective project management is achieved. Where the Japanese and Europeans have achieved this type of project management by design, this appears to be the evolving practice for US shipyards and suppliers.

Activities

Activities are the *execution* of the mechanisms and systems. In one sense the only best practice that matters here is, as the old Nike commercial says, "Just do it!" About all we can add to that is to ask the question "How do you know you've done it well?" In other words, we need to be concerned with metrics – how you measure your processes and your successes. We will cover that in two ways. First, we will look at best practices in *measuring* – what are good metrics to

collect and how do you make sure you collect them well? Second, we will summarize those we have gotten data on from our site visits – what have the results been from all of these efforts at supply chain management?

Metrics

There are usually considered to be two types of metrics: outcomes and processes. Outcomes concern measures of effectiveness – ways to assess cost/quality/timing outcomes. Process measures assess how well a particular process or mechanism or system is being used. The idea is that it is useful to know whether or how well a mechanism is being used so you can better understand why certain outcomes are coming about. For example, if a company claims to involve suppliers in design, but only does it in a very ineffective way, then we would not expect that company to have good outcomes in terms of cost/quality/timing. On other hand, if that same company involved their supplier well, but still did not have good outcomes, then we would have to question the utility of supplier involvement as a mechanism.

Most companies have some measures of outcomes, especially in the cost area. They will usually try to figure out (with varying degrees of success of course) what it costs them to make things and they almost always know what it costs them to buy things, although often important cost considerations are missed. The problem often arises in terms of how you put these things together. It may cost less to buy something from a certain vendor, but that may raise your costs elsewhere in your process – leading to the topic of lowest total cost, which we discussed above under mechanisms.

One producer of electronic instruments and industrial controls has an exceptionally strong program of continuous improvement within itself and with its suppliers. The company has evolved a set of metrics that they believe best reflects their performance (Air Force, 1996). These metrics are shown in Table 2, along with how often the company makes measurements. The performance of the company's suppliers is measured directly by four of the 20 metrics. However, 11 other metrics are really measuring the total performance of the company and its supply chain as an entity, so supplier performance is being indirectly measured by these as well.

Metric	Frequency	Metric	Frequency
Delivery Integrity		**Cost**	
Sales Orders	Weekly	Overhead as % of Sales	Monthly
Parts	Weekly	Purchase Variance	Weekly
Repairs	Weekly	Product Cost/Competitive Target	Monthly
Actual Delivery Cycle/ Quoted Delivery Cycle	Weekly	Overall Cost Reduction	Monthly
		Cost Reduction/Total Cost	Monthly
Material			
Inventory and Turns	Weekly	**Quality**	
WIP/Inventory Value of Output	Weekly	Internal/Process Defects	Weekly
Purchase Material/ Breakeven Purch. Mat'l	Weekly	Customer Returns	Weekly
Number of Active Suppliers	Monthly	Vendor Quality	Weekly
		Employee Involvement %	Monthly
Productivity			
Output Dollars/Person	Weekly		
Ratio of Supervision to People	Monthly		
Output Dollars/ Square Foot	Monthly		

Table 2. Business Metrics at an Electronics Company

It's much less common to have good measures of process, especially outside of the manufacturing arena. Motorola stands out as a company that focuses on measuring processes[8]. In the 1980s they became well known for making huge strides in product quality as a result of their "6 Sigma" effort. A critical foundation for their success with 6 Sigma was their focus on measuring quality processes. One way they did this was to develop a quality assessment they called the Quality System Review (QSR). This is a regular review of systems which involves measuring hundreds of aspects of the quality process. Conducted in the spirit of continuous improvement, it resulted in major process improvements. The QSR process is shared with suppliers so they can benefit from the process as well. The QSR is done at the business unit level and covers quality systems, new product and technology development, supplier controls, process operation and control, quality data, problem solving techniques, quality measurement systems, human resource involvement, customer satisfaction and software quality. The QSR evolves every few years in order to keep up with changes in expectations and methods. This process was so successful that Motorola has extended it to their product development process. Again, a set of measures was developed to assess the product development process and used within each division to measure the process. It's important to recognize that Motorola is an extraordinarily measurement-oriented company – a cultural trait developed over decades.

Marine Best Practices

At NASSCO we saw a variety of wall charts with numerous metrics, which were used to communicate the company's performance to the employees. Metrics we saw charts for included tonnage produced, items on back-order, cargo doors placed, reject rate, steel surplus, and steel safety stock. The results are shared with suppliers. Problem suppliers are brought in and given assistance to get on track.

[8] See the case study on Motorola in Fleischer and Liker, 1997.

At Avondale, Engineering rates suppliers on quality and on-time delivery. Purchasing measures delivery, price performance and responsiveness.

Evidence of Success

In this section we will only discuss marine industry successes, since others are not particularly relevant.

Marine Successes

One example that NASSCO is very proud of is that they delivered the first Sealift new construction ship three months ahead of schedule and within budget. They expect to deliver the second ship in the series five months ahead of the original schedule. They also delivered with far fewer discrepancies than usual, so few in fact that they are going to do without builder's trials for the remaining Strategic Sealift ships.

NASSCO measures on-time delivery performance for suppliers. On average, it is now 88% on time, with a goal of 95%. Nineteen of the top 75 suppliers achieved 100% on-time delivery in the month before we visited. The 8 FOS suppliers were 96% on–time. They also measure rejection rates for material – they are now down below 1%, with a goal of 0.5%.

Fincantieri achieved cost reductions from consolidated purchasing and improved design ideas in the EUROSHIP program of 12% in steel profiles, 13% in steel pipe, 17% in electrical cable, and 4.5% in anchors and chain. They also achieved cost reductions of about 7% from their strategic sourcing efforts in the CRUISE program, which focused on value analysis, co-design and volume buying.

Conclusions

In this section we provide the overall conclusions we have drawn from the visits we made to the firms in this study. These conclusions should be considered tentative since this is an interim report. Additional site visits will be made and more information will be collected, perhaps leading to different or additional conclusions. Because of the pervasive nature of government contracting in this industry, this section includes a discussion of the implications of government procurement practices.

1. **SCM in shipbuilding lags other industries**. The two shipbuilding firms exhibiting the most Best Practices have substantially more progress to make before they will match the leaders in the automotive or aerospace industry sectors. The use of these practices is relatively new in both companies, and evidence from other firms suggests that as long as half a decade or more is needed before the Best Practices really take hold. Top management needs to place, or maintain, a priority on supply chain management, and have the vision and stamina to stay the course.
2. **Most SCM approaches can work in shipbuilding**. Wide variations in supply chain management philosophies and practices exist in both the European and domestic marine industries, as is true of any industry sector. Some companies on both continents have instituted, or are instituting, many of the Best Practices, while others appear to have instituted almost none.
3. **SCM in shipbuilding is hampered by a lack of consensus on the structure, function and dynamics of the integration of ship production and SCM**. Real progress toward reducing material costs and improving delivery time depends on a deeper understanding of the integration of internal processes and those of suppliers into a shipbuilding "production system," analogous to the Toyota Production System. Successful manufacturing firms have learned to design supplier networks that minimize waste and maximize the benefits of supplier knowledge as well as process and material management capabilities. This is only in its infancy in shipbuilding.
4. **Good practice in SCM leads to business success**. Companies in the automotive, aerospace, construction and other industry sectors regarded as leaders in supply chain management are also leaders in important business metrics such as profitability, market share growth, product development time, and production cycle time. These companies attribute a significant part of their business success to their supply chain management philosophies and practices. Most of the Best Practices employed by these firms can be adopted or adapted by the domestic marine industry, and similar benefits can be expected. Almost all of the Best Practices we identified were in use in at least one marine industry firm.
5. **Shipbuilding lags in the use of electronic commerce technologies**. In general, this industry appears to lag both the automotive and aerospace industries in the use of electronic commerce (such as EDI and product data exchange) with suppliers. This was true for both the domestic and foreign companies we saw. In some of the companies we visited, communication is only by telephone and fax, and few companies exchange technical data with suppliers electronically.

6. **Supplier relations are more adversarial in the US**. Relationships between domestic shipyards and most of their suppliers tend to be significantly more arms length and adversarial than is the case in Europe. Experience from other sectors, particularly automotive and aerospace, shows that suppliers are much more responsive to the needs of their customers when close relationships exist and communication is frequent and open. The sourcing practices of some of the domestic shipyards have the effect of making relations with many suppliers far more adversarial than necessary.
7. **US shipyards lag in scheduling practices**. Domestic shipyards have much more difficulty in creating and maintaining accurate schedules for both engineering and construction than do the European yards we visited. Inaccurate schedules affect many aspects of supply chain management, including increased supplier costs, problems with timeliness and completeness of vendor-furnished information, and diminished trust between the yard and its suppliers. The root causes of poor schedules were not clear, and merit further study.
8. **DoD requirements do not prohibit good SCM**. DoD and statutory requirements do not prohibit the use of best practices, but they are often a constraint and at times prevent accessing commercial companies. CICA (Competition In Contracting Act), and variations in its interpretation, makes it more difficult to effect long term relationships with suppliers and to select suppliers on the basis of lowest total cost. The FASA (Federal Acquisition Streamlining Act) should remove remaining barriers to sourcing from commercial firms.

Government vs. Commercial Programs

The same basic processes for supply chain management appeared to be used by a company regardless of who the customer is. Certainly, there are variations in the nature of relationships between a yard and different owners, but we saw little evidence of those causing changes in the roles, responsibilities and relationships involving suppliers or in the mechanisms the company employs. The one major exception was Avondale's adoption of IPTs to satisfy the Navy's requirement. Companies also select a much larger percentage of off-shore suppliers for commercial programs, but the processes by which they select and manage those suppliers differs little from domestic sources. For example, Avondale selects suppliers based on the lowest price from a competitive bidding process involving multiple sources. They told us that the process is a Navy requirement, but that they would use the same process for a commercial program.

Many defense companies in all sectors cite DoD and statutory requirements as preventing adoption of best practices for supply chain management and as major barriers to accessing purely commercial firms. CICA and TINA are the two most notable problems. For example, CICA is often cited as a barrier to LTAs and strategic alliances, and most commercial firms simply will not countenance TINA. Despite these often-heard claims, all the discussed Best Practices are in place in many defense firms, and some are in place in the maritime industry. These requirements are not absolute barriers, but they can and do provide important impediments to some of the practices. Wide variations in how CICA is interpreted exist across the many DoD oversight groups.

The DoD drive for acquisition reform in general, and the Federal Acquisition Streamlining Act (FASA) in particular have important implications for supply chain management. FASA encourages the use of commercial contracting, eliminating the requirement for most FARs and TINA, when the item being purchased is *essentially* a catalog item. The key is that much greater

latitude is now allowed in defining *essentially*. It would appear that a substantial proportion of equipment items purchased in a ship program could be defined as commercial items, and the marine industry could adopt commercial contracting with almost all of its supply base.

DoD contractors often cite requirements for certified cost and pricing data and the Competition In Contracting Act (CICA) as barriers to SAs and LTAs. Clearly, they are not absolute barriers because there are so many examples in existence in the defense sector. They are impediments, however, that make creation of such agreements more difficult. In the case of CICA there is a need to prepare written justification for supplier selection and get government approval. The Truth In Negotiation Act (TINA) requirements make some companies nervous, and many commercial firms are unwilling to do business where TINA requirements exist. In such cases a strong effort is needed by the customer to help the supplier understand what TINA is and is not, and to use price competition as a substitute for certified cost and pricing data wherever possible.

Recommendations

Summary of Recommendations

- Recognize the importance of SCM as a key cost and schedule driver.
- Use the results of this and other studies to better understand the key process linkages and underlying dynamics of ship production and its impact on suppliers. Use that knowledge to build a shipbuilding "production system" to provide a better context into which Supply Chain Management Best Practices can be inserted.
- These SCM Best Practices should be demonstrated on a *pilot* basis before attempting widespread deployment. A pilot can be used to demonstrate the business case for the technology or business practice involved. It also insures that the technology or practice is modified to suit the specific situation for which it is being inserted.
- The Best Practices should not be adopted on an ad hoc basis, but rather in an orderly, planned manner. Figure 2 represents the approximate order in which this should be done. All shipyards that we visited are already doing some of what we recommend as Best Practices, however they still have a long way to go.
- In areas other than SCM, the industry should focus on improving scheduling practices, because problems with this are the source of several SCM problems, including VFI.
- The industry should seek to take advantage of changes in Federal procurement policies and switch to commercial contracting approaches if they aren't in use already.

Discussion

The US shipbuilding industry did not get in its current position by accident. The combination of dependence on a single government customer and protectionist legislation has resulted in a relatively uncompetitive industry. Unfortunately, the solution to this problem is not the removal of government protection – that would simply kill the industry off completely. The solution lies in a concerted effort by one or more companies in the industry to return to commercial competitiveness by focusing on competitive processes.

If we may make the analogy with the automotive industry one last time, the US automotive industry regained its international competitiveness by focusing on world-class processes – in quality, in manufacturing, in engineering. In the case of automotive, there was an recognized leader in the world – Toyota. The Toyota Production System and the Toyota Product Development System have been widely acknowledged as the roots of change in the US industry. Is there an analogous, process-focused system in shipbuilding? To our knowledge, the answer is "no." But that may be the saving grace for the US shipbuilding industry. Since there is no current "best" model, we are in a position to invent one and to profit by it.

We believe that it ought to be possible to develop a "production system" for the shipbuilding industry. Indeed, the Maritime Agility Group (1996) has taken a first step toward an outline of such a system. What remains is to assemble the details and learn how to make it work. In this study we have taken a small first step toward that end. Shipyard-supplier relations were a key

element of the Maritime Agility Group's strategy. Adoption of the 20 Best practices described in this report would result in a substantial improvement of shipyard-supplier relations.

While there is probably little doubt that all of the Best Practices are "good" things to do, which will have the most impact? Some may be of only minor value, while others may "make or break" a company. We currently have very little hard, financial data about the impact of these Best Practices as applied to the US shipbuilding situation. Furthermore, many of the Best Practices interact, or are dependent on other Best Practices being in place. For example, you may not be able to do Supplier Training effectively unless you already have a strategic alliance with a supplier; equally you may not be able to make widespread use of turnkey suppliers until you have a system in place for increasing supplier responsibility and for selecting suppliers based on lowest total cost.

The only way to find out which Best Practices have the most impact is to try them. Obviously such trials cannot be done on an industry-wide or even company-wide basis. Instead they should be done on a *pilot* basis. Most companies are familiar with the idea of conducting a pilot of a new technology or new manufacturing process within their own facilities. But, how do you pilot something that involves multiple companies, particularly multiple suppliers that work for multiple customers?

The automotive industry has some recent experience conducting multi-company pilots. As with the Best Practices, everything about these pilots is not transferable to the shipbuilding industry, but much of it certainly is. There have been two types of multi-company pilots used in the automotive industry: industry-wide and proprietary. These pilots all involve three phases:

1. Model the underlying system so that we can actually understand how they operate.
2. Develop metrics based on that model so we can measure the relationships among elements of the model.
3. Pilot the practices to validate the models.

Industry-Wide Pilots

The automotive industry has recently completed two industry-wide pilots in electronic commerce. The first was called the Manufacturing Assembly Pilot (MAP); the second was called the Automotive STEP (AutoSTEP) Pilot. MAP (AIAG, 1998b) involved 16 companies, including the Big 3 US automakers, a major supplier to them, and 12 second-tier suppliers all of whom were involved in the supply chain for automotive seats. MAP piloted the use of Electronic Data Interchange (EDI) for ordering and material release. It demonstrated savings that projected to more than $1B a year for the industry. It resulted in a major policy change by Ford and Chrysler to require their supply chains (to multiple levels) to use EDI as demonstrated in MAP.

AutoSTEP (AIAG, 1998a) involved 20 companies, including the Big 3 US automakers, two defense primes, eight first-tier suppliers to them, and seven second-tier suppliers. AutoSTEP piloted the use of STEP as an improved product data translation mechanism, as well as a variety of business practices that would enable them to take advantage of such translation. Specific dollar savings were not reported, but STEP was demonstrated to be a more effective means of translation than the alternatives. As a result, Chrysler has changed its product data exchange policies to encourage the use of STEP when appropriate.

Proprietary Pilots

Proprietary pilots are usually just that, not made know to the public. However, we do know of several multi-company proprietary pilots in the automotive industry. In one example, several small and mid-sized suppliers are piloting a virtual enterprise approach to jointly provide a complex manufacturing system to their customer. This will involve a "live" project in which a system is actually built using several new (to them) technologies and business practices. An independent evaluation team is documenting the process and the financial impacts of the pilot. Since this is currently under way, we have no results, although it does appear to be proceeding smoothly.

A Potential Shipbuilding Pilot

As one example of what might be done in the shipbuilding industry, consider a pilot that looks at solving the problem of late and/or inadequate Vendor Furnished Information (VFI). Such a pilot would start by building a model of what *causes* late and/or inadequate VFI. That model might look like Figure 4[9].

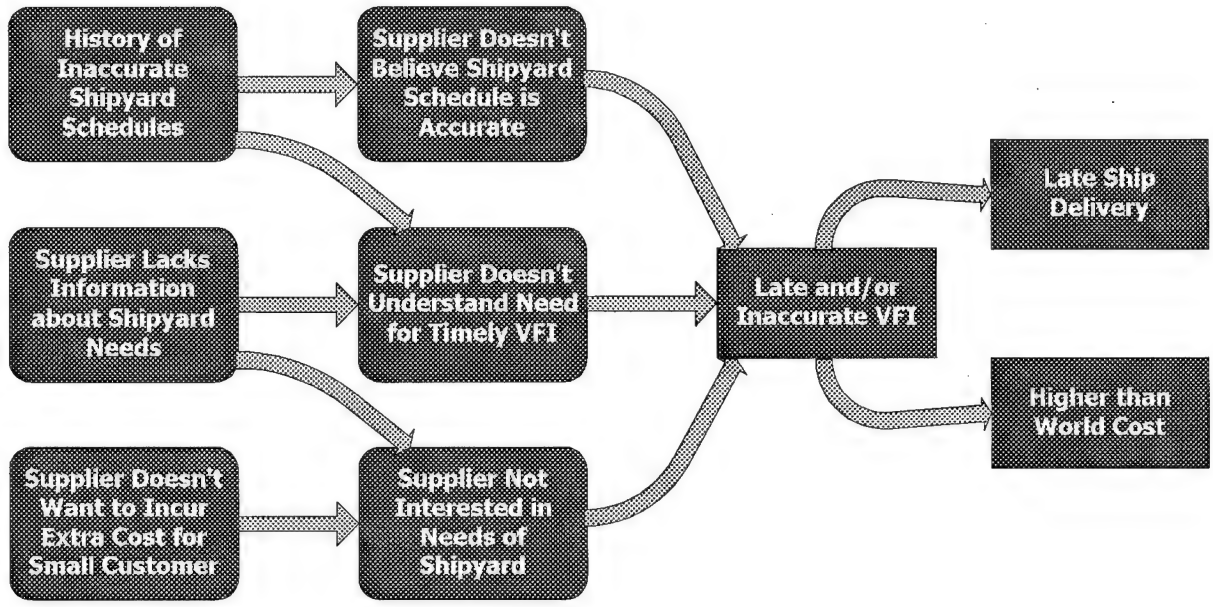

Figure 4. The VFI Problem

In Figure 4 VFI problems are a contributing cause to late ship delivery and high costs. We know this is the case because individuals from different functions in several shipyards have told us about it. The VFI problems are caused (perhaps at different times or with different suppliers) by three problems:

- some suppliers just don't believe the schedule put out by the shipyard and therefore don't bother to try and deliver their data on time;

[9] We have not done a complete analysis of the causes of this problem since that was not a focus of the study. This model is presented for illustrative purposes only.

- some suppliers don't understand why their data is important to the shipyard, and therefore don't bother to get it there on time; and
- some suppliers just don't care very much about the shipyard as a customer.

If we go back a step, we find that:

- suppliers don't believe the shipyard schedule because it has been inaccurate in the past;
- they don't understand why their data is important because they don't have a good understanding of what is important to the shipyard, and because the shipyard has a history of inaccurate schedules (telling the supplier that schedule is not important to the shipyard); and
- they're not very interested in the needs of the shipyard partly because the shipyard is such a small customer, and partly because they don't understand those needs very well.

The solution is driven, at least indirectly, by the problem model. Figure 5 shows a possible model of a solution involving a variety of Best Practices. One of the Best Practices, *Integration of Planning and Schedule*, affects the timing of VFI from a technical sense. Integration of Planning and Schedule means to integrate the supplier into the customer's planning and scheduling. We have seen at least two examples where this appears to have affected the timing of receiving VFI – NASSCO has no VFI problems with its joiner work supplier, Hopeman Brothers. Hopeman is tightly integrated into NASSCO's planning and scheduling processes. However, NASSCO has VFI problems with other suppliers. Fincantieri reported no VFI problems and it also reports tight planning and scheduling integration with a wide range of suppliers. This is only a correlation, not formal proof of this connection, but we believe it is highly suggestive.

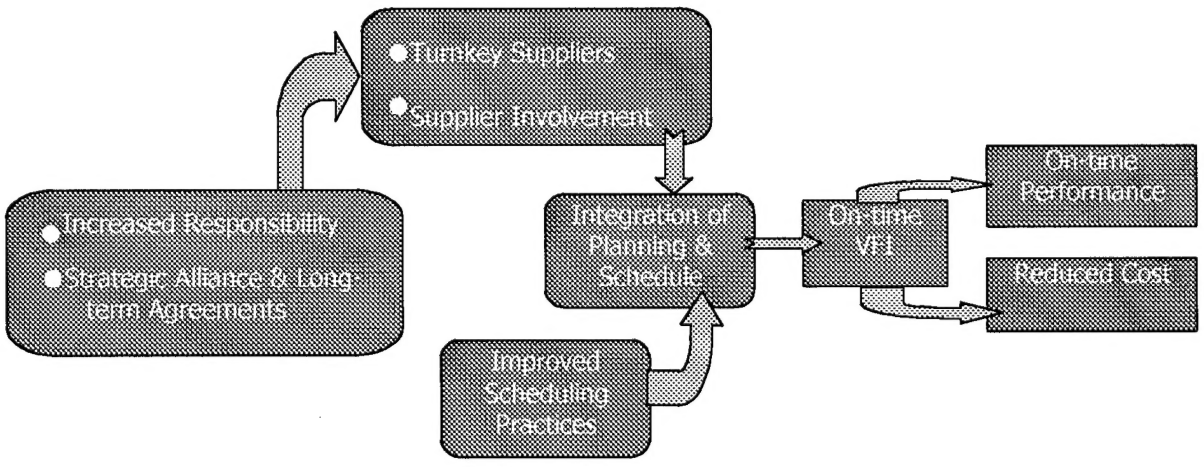

Figure 5. Impact of Best Practices on VFI

If we go further to the left in the diagram, the causal connections get more speculative, but we believe the logic to be fairly persuasive. Suppliers can only be tightly integrated if they have a close working relationship with the shipyard – hence the suggestion that *Turnkey Suppliers* and

Supplier Involvement lead to *Integration of Planning and Schedule*. Tight integration is worse than useless if the base scheduling process is poor, thus the connection from *Improved Scheduling Practices*. This was not listed as a Best Practice, but it was described as a problem for many shipyards. *Increased Responsibility for Suppliers* and *Strategic Alliances* are Best Practices that are approaches to achieving Turnkey Supplier status and Supplier Involvement.

Once a model of the solution was developed, it would be tested in a live situation, but on a limited scale, with one or two shipyards and a handful of suppliers. The test would be conducted in a way that insures the collection of information about both the process and the outcomes of the effort. The results of the pilot would then be made available either publicly, in the case of an industry-wide pilot, or within the participating companies in the case of a proprietary pilot.

This approach to demonstrating the benefits of Best Practices has been successful in the automotive industry, which historically has been very conservative and resistant to change. We believe the shipbuilding industry is no more resistant to change than automotive was a decade ago. Therefore, we have every reason to believe that a process like this could work in shipbuilding.

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